OBSERVATIONS

ON

COLLIERY ACCIDENTS.

--- THESIS ---

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by

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Observations on Colliery Accidents.

1. Introduction.

2. Statistics.

3. Detailed consideration of Accidents,

    (a) Accidents peculiar to Collieries,

    (b) Other Accidents.

4. The Future.

5. Conclusions.

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1. Introduction.

The recent history of the coal trade has brought the problems of the industry much into the news, and, naturally, the point of greatest interest to the ordinary citizen is the production side - the side that affects his comfort in winter.

But there is one disquieting feature about the trade that deserves the Medical Profession's interest and study, namely, the extraordinarily high accident rate. Although the question of man-power in the coal trade is no direct concern of doctors, yet an efficient accident service can play a part, in helping the return of injured men and in reducing the number of partially and totally disabled miners.

It appears to the writer obvious that there must always be a relatively high accident rate, and therefore the problems associated with the treatment of the injured are likely to be with us for many years. Interest in the accident surgery of miners consequently should not be ephemeral, and it must be stated categorically that rehabilitation centres are not enough.

By its very nature mining is dangerous. If it is remembered that the winning of coal involves the removal of one of the geological strata, perhaps at a depth of 300 yards or more, it is obvious to the most uninformed that the "roof" pressure will be enormous. Hence the

great tendency to falls of stone, due to movement of the "roof" leading to breaks in the rock. (See Figs. 1 & 2).

Over and above the dangers due to natural causes, the introduction by man of machinery underground, e.g. Coal-cutters (Fig. 3), Mechanical Conveyors, Haulage Engines; and the use of a miniature railway system in a confined space (Fig. 4), all tend to added risk of accident. In actual fact, it is found that (1) accidents due to falls and (2) haulage accidents together constitute about 42% of the total underground accidents. In a recent consecutive series of 250 underground accidents seen by the writer, 67 were caused by falls and 38 were haulage accidents. Accidents caused by machinery, coal-cutters, conveyors etc. are likely to increase as it appears from the recent press discussion that there will be a great increase in the near future in mechanization of British collieries.

Major explosions underground are not considered in this paper as the writer has no personal experience of such. Minor explosion accidents, shot-firing accidents, are seen fairly frequently and call for later comment.

The Miner.

The miner, himself, is worthy of careful study in any survey of the accidents to which he is prone. Generally speaking, miners live in small isolated communities, e.g. the mining villages of Lanarkshire, Ayrshire, Northumberland, Durham and South Wales, and this segregation of the miner

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FIG. 1.

A fall of stone. Note the bending of the steel straps.

FIG. 2.

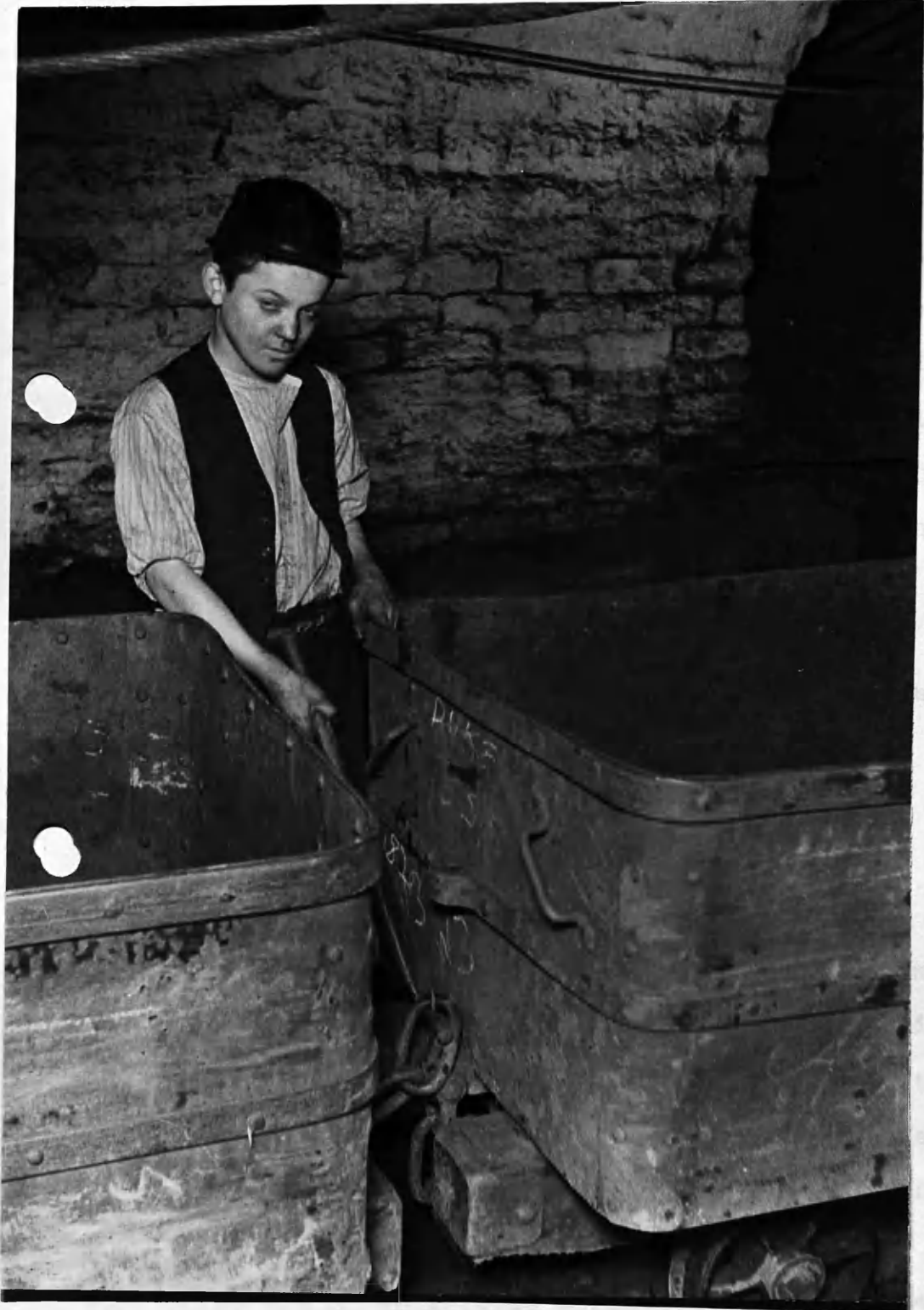Inspecting the "roof".

Note the loose stone which may fall at any moment.

FIG. 3.

Showing a coal-cutting machine.

The coal seam in the background.

FIG. 4.

6

This gives an impression of the size of the "tubs"
for transporting coal, stone etc.   "Tubs" are a prolific
cause of accidents among boys.

brings about a strong herd sense and an innate conservatism. By comparison, the mining town of Ashington, where the writer works, boasts a population of 32,000 and of these, approximately 9,000 are miners. The town depends for its prosperity and livelihood on one large coal company. The amenities consist of cinemas, dance halls, social clubs, dog track etc., so that this particular community forms in essence a small town, as distinct from the mining village.

In normal times the miner begins work in the pit as a boy of 14 and he is usually the son of a miner. This is an important point, as he is brought up in an atmosphere where the trials and tribulations of a miner's life are accepted, and he adapts himself with rapidity to the conditions. By way of contrast, the recent introduction of so called "Bevin Boys" to the pits in many cases caused distress amongst these entrants to the coal trade.

The miner is of average physique, though many of the younger men (putters, for example) show an excellent muscle development and are big boned. Many of the older men are rather thin-faced and the typical blue scar is prominent. Frequently, rheumatic complaints are met with and it is a common finding in the elderly miner that the knees, hips and spine show a degree of osteo-arthritis. This feature has been noted in West of Scotland miners by Miller (Ref. 1). Very often the miner accepts accidents as his natural lot and seldom grumbles, but he demands his rights and will fight hard if he thinks he is being deprived unfairly of

compensation money.   He is a rough fellow, full of life, and with an over-riding sense of humour.

As a patient, he excels.   He takes his knocks stoically and bears pain well.   He co-operates willingly in any treatment and often one has more trouble preventing his premature return to work than in getting him to work.   He is very willing to work hard to hasten his recovery and he enjoys the competition of class exercise.   In my experience of the Northumberland miner, malingering is a rare phenomenon.

One interesting feature that deserves passing mention is the persistence of extraordinary superstitions in the mining community.   To a medical man, many of these superstitions appear quite without point, e.g. if a miner sprains his wrist, frequently, when convalescent, he ties one or two strands of wool round the wrist to strengthen it. If he has a weak back, the miner has great faith in a piece of flannel worn across the loins, but this flannel must be red!   As regards external applications, vinegar and brown paper is still popular with a few.   "Rubbing bottles" are very popular and apparently the hotter the better.   Olive oil is a great favourite for all forms of post-traumatic stiffness and usually it is massaged into the part by the miner's wife.   One superstition that appears to be dying rapidly is the belief that washing the centre of the back produces weakness.   Probably the institution of pithead baths has effectually banished this peculiar idea.

As mentioned above, osteo-arthritic changes are often found in elderly miners in the course of routine x-ray examinations. The spine is the most frequent site, but the knee joint and hip joint (in that order) are also affected. A corollary to this is that sprains and strains, which might be expected to clear up quickly, often, in theminer of 50, are extremely difficult to cure and at times permanent disability is left. The cause of this osteo-arthritic change is almost certainly repeated subclinical traumata and this view agrees with the site of the disease, spine, knee and hip, as the regions most subject to sprains and strains. The position of the filler at the coal face, sitting back on his heels with his body bent forward, twisting and untwisting his spine as he shovels in a confined space, provides proof of the importance of the traumatic factor in this disease. (Figs.5, 6 & 7).

In a recent exhaustive study of the changes in the knee joint at various ages, Bauer concludes that :-
(a) The most constantly observed concomitant to primary degenerative joint disease is increasing age,
(b) There are two fundamental causes which are probably the predisposing factors in every example of degenerative joint disease viz.(1) The paucity of the cellular elements of the articular cartilage, its remoteness from blood supply, low respiratory rate, and extremely limited faculty for autogenous repair and (2) the effect of mechanical stress and strain resulting from joint function upon a tissue whose specific

means of resistance to such use has been depleted.   (Ref.2).
It is interesting that experience among miners largely
confirms the above view.

One other point must be mentioned in this introduction.
In assessing recovery from an accident, it is most important
to bear in mind the type of work a patient is returning to.
A sedentary worker can carry on his duties quite efficiently
with a walking plaster.   A general practitioner of medicine
with a stiff right index finger can manage a busy practice
despite his disability.   But, when it comes to returning miners
to their arduous work, the functional recovery must be of a
very high order.   This point must be emphasized, that, in any
assessment of the treatment of mining accidents, the functional
recovery must be good, and it must be rounded off with the
hardening process of rehabilitation.   It is gratifying to see
that most of the British coalfields are now provided with
excellent rehabilitation facilities, and, in making this
statement, no disparagement is intended towards the work of a
hospital massage department.   Previous to the establishment
of the Rehabilitation Centre of the Northumberland miners,
the author saw much excellent work carried out by a team of
enthusiastic masseuses, who were imbued with the idea of
patients treating themselves by active exercises rather than
with the passive treatment of conventional physiotherapy.
Even with the limitations of such a department, the general
standard of recovery was high and the work done there was
appreciated by those chiefly concerned - the miners.   (Ref.
3 & 4).

FIG. 5.

Showing a filler at work. Note how he sits on his heels and how he twists and untwists as he fills the tub.

FIG. 6.

Another picture of a filler at work.   Note the
loose coal in the foreground.

FIG. 7.

A back view of a filler. The position shows the
importance of full knee flexion to a coal-face worker.
The coal seam is well shown on the left of the picture.

2. Statistics.

It is extremely difficult, if not impossible, to give accurate statistics of colliery accidents for the whole of Great Britain, as many of the minor accidents are not reported. The following table is taken from the final report of the Inter-departmental Committee on the Rehabilitation of persons injured by accidents (Ref. 5) and gives figures for all industries :-

TABLE 1.

The number of new cases of disablement by accident in which compensation was paid in 1937 in each of the seven major industries of the country :-

Shipping	7,332
Factories	218,532
Railways	18,176
Docks	9,861
Mines	139,230
Quarries	6,861
Constructional Work	9,658

It is obvious that the problem of accidents in mines is a very big one and yet, whilst impressive to anyone unfamiliar with colliery accidents, the figures in Table 1 do not bring home the amount of suffering and loss of work entailed in the coal trade.

The following table is constructed from figures kindly given to me by Dr. Fisher, Chief Medical Officer to the Ministry of Fuel and Power. This table gives a much clearer indication of the heavy price that has to be paid yearly in

the coal mines (Ref. 6).

TABLE 2.

Number of persons injured at mines under the Coal Mines Act in Great Britain during the year 1942 (excluding the stratified ironstone mines in Cleveland, Lincoln and Northampton) :-

Nature of Injury	Underground Workers	Surface Workers
Fractures.		
Thigh	165	28
Leg	958	74
Arm	306	75
Spine	223	11
Pelvis	154	5
Injuries and/or other Fractures.		
Head	8,646	790
Arm	12,496	1,340
Hand	44,954	5,149
Thigh or Leg	28,585	2,619
Foot	15,708	1,910
Eye	8,599	727
Back	13,624	1,044
Other parts of the body	15,790	1,723
TOTAL	150,226	15,495

A graphic illustration is given below and is copied from Vernon (Ref. 7):-

The incidence of accidents in the coal mines compared with other industries (data from Home Office figures for 1938).

FIG. 8.

(AFTER VERNON).
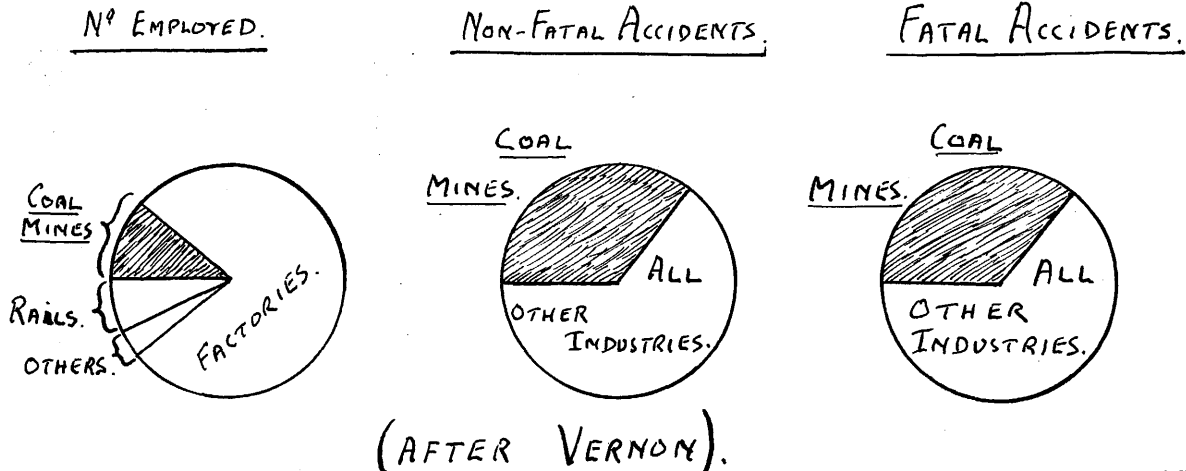
The writer's experience has been obtained in dealing with the accidents met with in a large group of collieries in Northumberland. The accidents from this source are all treated at a local hospital (Ashington Hospital) under the writer's supervision. The following table is compiled to indicate the size of the problem met with in this large group of collieries.

TABLE 3. (Author's figures).

Total accidents reported in 1944	5,283
Total accidents over 3 days disability	2,533
Total shifts worked	2,324,949
Accidents per 1,000 shifts worked	1.089
Average number of men employed	9,028

Taking the total number of accidents with disability lasting more than 3 days, and excluding Industrial Diseases and immediate Fatal Accidents, the following table has been compiled to indicate in a broad way the different types of injuries sustained :-

TABLE 4.

Classification of accidents causing over 3 days disability, excluding Industrial Diseases and immediate Fatal Accidents, for the year 1944 :-

Type of Injury	No.	Percentage of total	Deaths
1. Contusions and Bruises	851	36.61	-
2. Lacerations	698	30.03	-
3. Strains and Sprains	274	11.74	-
4. Fractures and Dislocations	261	11.23	1
5. Knee Injuries	106	4.56	-
6. Eye Injuries	69	2.96	-
7. Minor Amputations	25	1.07	-
8. Hernia	19	0.81	-
9. Burns and scalds	12	0.51	-
10. Severe Head Injuries	5	0.20	-
11. Internal Injuries	3	0.12	1.
12. Major Amputations	1	0.05	-
TOTAL	2,324	100	2

This simple analysis is striking. The first three groups - Contusions, Lacerations and Sprains - looked upon as trivial, constitute 78% of the total number. This is strong evidence in favour of the establishment of an efficient accident service in the coal fields. It is interesting also to observe that in one year there were 106 cases of internal derangement of the knee joint. This bears out the surgeon's description of Northumberland as a "glorious cartilage county"!

Referring back to Table 4, it is of considerable interest and importance to classify further the main types of injury referred to in Table 4, according to the anatomical site, and Tables 5, 6, 7 and 8 give this information.

TABLE 5.

Analysis of 851 contusions and bruises according to site of injury :-

Site.	No.
Trunk	250
Leg	225
Foot	151
Hand	121
Arm	91
Head and face	13
TOTAL	851

TABLE 6.

Analysis of 698 Lacerations according to the site of injury :-

Site.	No.
Hand	503
Head and Face	90
Arm	44
Leg	37
Foot	18
Trunk	6
TOTAL	698

TABLE 7.

Analysis of 274 Sprains and Strains according to site of injury :-

Site.	No.
Back and Trunk	198
Wrist	40
Ankle	36
TOTAL	274

TABLE 8.

Analysis of 261 Fractures and Dislocations according to site of injury:-

Site.	No.
Hand	113
Foot	65
Leg	22
Ankle	13
Both Bones of Forearm	12
Ribs	8
Femur	5
Spine	6
Others	17
TOTAL	261

Reviewing Tables 5 to 8, some interesting and instructive points emerge and Table 9 helps to emphasise various important facts..

TABLE 9.

Accident	Total No.	No. involving Hand	No. involving Foot	No. involving Head
Contusions and Bruises	851	121	151	13
Lacerations	698	503	18	90
Strains and Sprains	274	40	36	-
Fractures and Dislocations	261	113	65	-
TOTAL	2084	777	270	103
Percentage		37.3	13	4.9

It is noticeable that the hand figures very prominently in this table, and this emphasises two points, (1) The importance to the coal trade of all safety measures to prevent hand injuries, and (2) The importance of an efficient accident service in colliery districts, and such a service must appreciate the enormous economic importance of all hand injuries.

Sufficient has been said to demonstrate the magnitude of the problems, and the importance of an effective surgical service in colliery districts.

3. Detailed Consideration of Accidents.

Many colliery accidents are in no sense different from civil accidents e.g. the multitude of bruises and lacerations that the miner sustains.   But the position of the miner, and the methods used in gaining coal, produce some quite characteristic injuries.   It is also to be remembered that the miner often underrates his injury e.g. he may say that some "ramble" came away and caught him, whereas in actual fact, he may have been buried by half a ton of stones of various sizes!   The natural forces are very great, and a stone weighing 100 lbs., in falling a distance of 4 feet, gains a very considerable momentum.   (Momentum $M = \frac{1}{2}MV^2$) This should be remembered when taking the history of a back injury.   Most people are familiar with the blue scar on a miner's face or forehead.   The pigmentation is due to embedded particles of coal and appears in no way to be inimical, apart from the deformity.   There is an interesting popular belief amongst miners that a wound produced by coal heals more kindly than one caused by stone and clinical experience appears to support this view.   A characteristic injury is that caused by a shot-firing mishap.   A shot fails to go off at the expected moment and a miner may go forward to investigate, when a delayed explosion occurs. Obviously the result may be instant death, but in a personal series of 14 shot-firing accidents only one death resulted. Usually the miner is peppered with tiny fragments of coal, dust and powder.   The appearance is extraordinary as the

FIG. 9.

Drilling.

After the hole is drilled in the coal, a charge of
explosive is inserted and fired, thus "bringing down" the
coal ready for filling.

face, arms and chest suffer most damage. The treatment of this accident calls for special notice later.

Coal-cutter accidents are fortunately rare as, when they do occur, they are often of the most serious type. The coal-cutter (See Fig. 3) is a machine, heavily constructed, and carrying at one end a large disc to the edge of which picks are attached. The disc revolves rapidly and cuts its way into the coal seam. If it should happen that this revolving disc strikes a miner, the resulting wound is of a particularly mutilating type.

Conveyors are now used frequently underground and the typical accident happens when a miner's arm is caught between the belt and the drum. Several of these cases under the author's care have presented features indistinguishable from Volkmann's ischaemic contracture.

Group A, Accidents Peculiar to Collieries.
1. The Shot Firing Accident.
After the coal-cutter has undercut the coal seam, a drill hole (See Fig. 9) is made in the coal and a charge of explosive inserted. The miner retires to a safe distance and the charge is fired electrically or by means of a squib. The accident occurs if the charge explodes prematurely, or if, the charge failing to go off, someone goes forward to investigate and a delayed explosion occurs.
Clinical features. The explosion may cause most gross injuries, as in a case seen by the author in 1944. This

man was extensively peppered; both forearms were torn to shreds and he had two penetrating chest wounds; he died within an hour and a half. Most cases fortunately are not so severe. Frequently the face, forearms and chest are peppered with minute pieces of coal, stone and dust. Shock is variable, but it is noticeable that, where the chest is badly affected, shock is correspondingly increased. The fragments of coal etc., travel with relatively low velocity and as a rule do not penetrate the tissues deeply; in actual practice the great majority are found embedded in the skin. One unusual case under the author's care received the force of the explosion on his leg. He sustained a severe compound fracture of the tibia and fibula and the overlying skin was extensively destroyed. Fortunately, small islets of skin were intact and a judicious excision of the wounds, plus immobilisation in plaster, gave an excellent result.

Treatment. Assuming that there is no other serious injury and that the general condition is good, the patient is anaesthetized with gas, oxygen and ether. The removal of such multiple foreign bodies is difficult and is best effected by means of (1) Volkmann's spoon, and (2) a stiff bristled nail brush. The skin is thoroughly cleansed with soap and water and sterilized with acriflavine or picric acid. The affected parts are draped with towels. The spoon has to be used with vigour. Only slight haemorrhage ensues, but where an extensive surface is treated, there

is a brisk serous exudate.   A final scrub with a brush completes the task.   The most suitable dressing is acriflavine emulsion B.P., or sulphanilamide tulle.   In a matter of 4 to 6 days any facial dressings can be removed and the skin annointed with lanoline or vaseline.   The results are usually gratifying.   Occasionally, where a localized area of skin has been destroyed, healing by granulation follows, and if this area is close to an eyelid, an ectropion is likely.

Complications.   Sepsis of any severity has not been noted. Tetanus, likewise, is unknown.   A retained piece of stone or coal is the commonest complication.   Complaint is made of a slightly tender nodule and the history suggests the diagnosis.   Often the foreign body can be palpated, and removal is easily effected under local anaesthesia. Ectropion has been met with on two occasions.

2. Coal-cutter Accidents. (See Fig. 3, p. 5).

Coal-cutter accidents are caused by (1) the revolving disc coming in contact with a man or (2) the machine "kicking back" out of the cut when the picks strike an unusually hard substance.   Where the accident is due to contact with the picks, the resulting wound is usually very gross.   A case seen in 1934 was of this nature.   The picks in this case caught both popliteal fossae.   It is superfluous to describe the injuries in detail, as all the tissues down to the bone were torn to shreds, and when admitted to hospital, he was profoundly shocked and died

within an hour.   Minor injuries of the same nature are met with and the treatment of such cases must be very thorough, as muscles are lacerated.   It is very important to lay open the wound widely and remove all devitalized tissue.   Such wounds are best treated by the open method.   Later a secondary suture can be performed.   (Ref. 8 & 9).

When a coal-cutter "kicks", if it comes in contact with a man, the result may be no more serious than a bruise. But, owing to the cramped space underground, there is always a great danger that a severe crushing injury may result, the miner being caught between the cutter and the props. Such a case seen in 1938, resulted in a gross compound fracture of the skull.   It is obvious therefore that the coal-cutter is a machine to be handled with great care and "safety first" should be the motto of those using it.   It will be noted in Fig. 3 that the cuttermen are wearing safety helmets, safety boots and protective gloves, all designed to minimize the danger.

3. Conveyor Accidents.

Many modern collieries employ conveyors underground. The coal is shovelled by the filler on to the conveyor and the conveyor belt carries the coal along for 50 to 100 yards to the tubs.   The belt of the conveyor is carried on rollers and, apart from minor accidents caused by coal spilling from the conveyor, several of a more serious type have been caused by a miner's arm being caught between the belt and

the roller.   In one such case, the R. arm was almost completely avulsed.   In other cases of less severity, the injuries vary from fractures of the bones of the forearm to crushing of the soft tissues.   These crush injuries are of great interest.   There may be nothing obvious other than diffuse swelling of the limb.   The fingers are held in a flexed position and the hand has a livid hue.

Examination reveals a general increased tension of the arm and diffuse tenderness.   Several cases have shown patchy anaesthesia of the fingers and hands;   tension blisters are common.   In no case under the author's care has the crush syndrome developed (Ref, 10). Another interesting feature of these crush injuries is that a mild Volkmann's contracture has been noted on two occasions.   In neither of these cases was the contracture progressive and the response to treatment was gratifying.   In no case has the pulsation at the wrist been abolished.

Treatment.   Any tension blisters should be snipped and an antiseptic dressing applied.   The arm is immobilized in a plaster slab with the elbow joint at right angles.   This slab extends from the metacarpo-phalangeal joints to mid-arm.   The slab is retained in position with a calico bandage.   Thereafter, the limb is kept elevated and the patient is instructed in finger exercises.   This method of treatment has been successful in all cases excepting the two with Volkmann's contracture.   In these it was necessary to apply a Cramer wire outrigger splint with elastic slings

attached to each finger so as to extend the fingers passively.
(See Fig. 10).   FIG. 10.
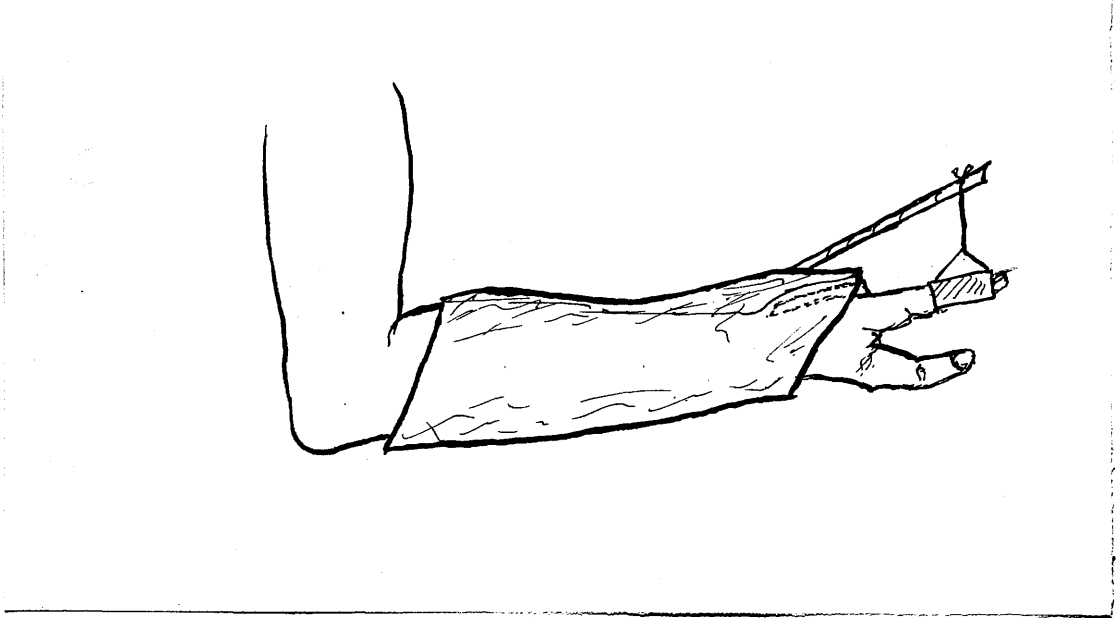
Showing passive extension of fingers.

Complications.   Volkmann's contracture has already been
mentioned.   In one case a small area of skin was so damaged
that it sloughed and a small split skin graft was necessary
to hasten healing.   The effect of the crushing on the nerves
appears to be quite transitory and in no case was causalgia
met with.

4. Burns from lamps.   Many of the lamps used underground
are electric in type, and the battery is carried attached to
the miner's belt at the back.   These batteries are of the
accumulator type and may contain acid or alkali.
Occasionally leakage of the acid or alkali leads to a burn
of the buttock or loin.   Usually the surface area of such

a burn is not extensive but healing is very protracted.

Clincial features.   There is an area of necrotic skin
occupying the centre of the burn and surrounding this, for
a distance of about $\frac{1}{4}$", there is a zone of hyperaemia.
The slough of dead skin is very slow to separate, frequently
taking 4 to 6 weeks.   When the slough does come away, a
healthy granulating surface soon appears and the epithelium
rapidly grows in from the edge.

Treatment.   The first aid treatment should comprise the
application of a weak neutralizing solution.   The problem,
thereafter, is the treatment of the necrotic skin.   Probably,
in the smaller burns, the ideal treatment would be to excise
the whole of the burnt area, but the writer has had no
opportunity of treating such cases.   In the larger burns,
dressings of Eusol are helpful in hastening the separation
of the slough.   After the slough has come away and a healthy
granulating surface remains, skin-grafting should
be carried out.

Complications.   No complications of any note have been seen.
In several cases the scar has been remarkably sensitive and
tender, but time appears to cure this.

5. Strains of back.   In many respects this injury is one of
the most characteristic of all colliery accidents.   It is
also a frequent type, forming about 10% of all accidents.
In a recent series of 250 accidents seen by the author, 24
were of this nature.   The accompanying table gives an idea
of the frequency and severity of the injury:-

FIG. 11.

Lifting a derailed tub.

A fruitful source of back strains.

TABLE 10.

Total No. of Strains of Back occurring at one colliery in 1944	79
Total working days lost	1,469
Average time lost per case (under 6 months)	18.6
Cases with disability exceeding 6 months	1

<u>Causation</u>.   It is very common to be given histories as follows:

(a) A miner is lifting a derailed tub, or a heavy stone or girder, when he is suddenly seized with an acute pain in the back, and is at once disabled.   (See Fig. 11).

(b) Two men are lifting a heavy girder, or prop;   one lets go his hold prematurely and the other has to make a sudden violent exertion.

<u>Clinical features</u>.   When seen immediately after the accident, the patient is obviously in great pain and is quite disabled. He holds a hand over the site of injury and stands with his knees flexed and his spine bent slightly forwards - indeed in a position very reminiscent of the well known advertisement for backache pills !   The amount of pain and disability may hoodwink a first aid man into thinking that he is dealing with a fracture case.

The attitude described is often retained, more or less, until the patient is convalescent and has got rid of pain and muscle spasm.

Recently the author studied a series of 52 such cases from the point of view of symptomology, and the following findings were obtained :-

Symptoms and Signs met with in 52 men suffering from

Acute Back Strain.

TABLE 11.   A. Symptoms.

	Symptom.	No. suffering.
1	Pain	52
2	Pain on coughing or sneezing	33
3	A sensation of something "tearing" at the time of accident	27
4	Referred pain	19
5	Pain on flexing the back	10
6	Local pain when walking	12
7	Pain when raising the arm	4

TABLE 12.   B. Signs.

	Sign.	No.
1	Local tenderness	52
2	Lumbar rigidity	30
3	Total scoliosis	7
4	Local swelling	0
5	Pain on straight leg raising	52

TABLE 13.   C. Site of Tenderness. (See also Fig. 12).

	Site	No.
1	Sacro-spinalis muscle, just above the iliac crest	16
2	Sacral attachment of sacro-spinalis muscle	8
3	Sacro-spinalis muscle midway between iliac crest and 12th rib	7
4	A point just below the 12th rib	5
5	The origin of gluteus maximus	5
6	A point close to the spine and above the 12th rib	7
7	Mid-line over an interspinous ligament	3
8	2 and 5 combined	1

FIG. 12.
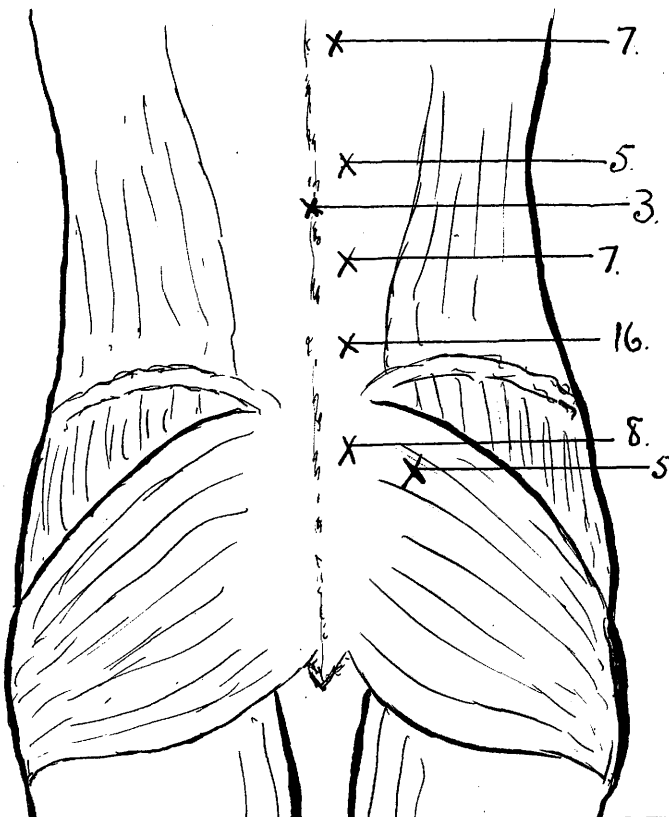
Anatomical Demonstration of site of tenderness in 52 Back Strains.

Watson Jones (Ref.11) gives as the commonest sites of myo-fascial injury :-

(1) The origin of the sacro-spinalis from the back of the sacrum between the spinous processes and the posterior superior spine,

(2) The origin of the gluteus maximus from the posterior superior iliac spine and the sacro-tuberous ligament.

My figures do not quite correspond with this.

Clinical features. The patient is very obviously in pain, and often has to be carried out of the pit on a stretcher. If walking, the attitude of flexion is very characteristic, and any attempt to straighten the back causes severe pain. On inspection, the back is seen to be held in a slightly flexed position, but with a rigid lumbar spasm. Total scoliosis is occasionally seen, (7 times out of 52 cases). There is no visible swelling or deformity. Palpation elicits a well marked area of tenderness and if firm pressure is applied the patient tends to fall to his knees.

Even if seen several days after the accident, no evidence of bruising is seen, such as one would expect with a tear of the muscle fibres.

Pathology. There is no subject in all orthopaedics that is so widely debated as the nature of these injuries. It may be stated, with fairness, that there are two rather opposing views - (a) that all are of the nature of myo-fascial strain, (b) that a great number of these injuries are due to intervertebral disk injury, with or without disk prolapse.

Probably the truth lies somewhere between. The author accepts the myo-fascial strain as a very genuine lesion, and no evidence has yet shaken this belief; but this does not mean that disk injury is not met with. From Table 10, p. 32, it will be seen that in 78 cases of back strain, the average disability period was 18.6 days. This does not suggest that in any of these cases there was a serious disk injury with consequent prolonged muscle spasm. Yet it must be admitted that, in the writer's experience, a small proportion of cases do not respond to ordinary rest and physiotherapy, and it may well be that a number of cases of disk injury have been overlooked.

The Lancet (Ref. 12) in a review, says - "What is the pathology of an acute low back strain? Is it a simple myo-fascial injury, or a deeper lumbar and lumbo-sacral strain, and if the latter, are we to regard intervertebral disk prolapse as an integral part? It would be stupid to refuse to admit that there may be several different local lesions; but equally short-sighted to ignore the increasing recognition of lumbo-sacral strain with associated disk prolapse as a causative factor".

How is one to diagnose a simple myo-fascial injury from a more serious disk prolapse?

Crisp (Ref. 13) states that - "these cases (i.e. disk injuries) are distinguished by extreme and persistent spasm of the lumbar portion of the erector spinae muscle and hamstring spasm of less severity".

Burns and Young (Ref. 14) discussing the signs of disk injury, say - " some have loss of the lumbar hollow and a few have a well marked sciatic scoliosis .... The most notable and consistant characteristic of a disk protrusion is restriction of movement in the antero-posterior plane while sideways bending is free."

While these statements are clear and definite, unfortunately in the author's experience of miners' back strain, lumbar spasm or rigidity is equally common in myo-fascial injuries, which injuries have recovered completely in a matter of a few weeks.   Indeed, in 7 of the series of 52, sciatic scoliosis was noted and all these cases recovered completely, yet Burns and Young state categorically that - "...........almost the only cause of sciatic scoliosis is protrusion of a disk".   (Ref. 14).

It is obviously very difficult to segregate the more severe case from the simple strains of ligament or muscle, though perhaps the increased realization of the importance of disk injuries may lead in the future to more accurate diagnosis.   The following is suggested as a useful help in Differential Diagnosis :-

	Simple Myo-fascial Strain	Disk Injury
History of Injury	Yes.	Not always.
Tenderness	Yes.	Yes.
Muscle Spasm	Temporary.	Marked and prolonged.
Relief from Novocain Injection	Yes.	No.
Flexion of Spine	Limited temporarily.	Severely restricted and no improvement as time goes on.
Lateral movement	Limited if the movement tenses the injured structure.	Not limited.
Response to rest and physiotherapy	Usually prompt.	Poor.
Tendency to relapse	Slight.	Marked.

Treatment

(1) Myo-fascial Strain.   In this district many back strains are treated by the family doctor, and often with great success. The customary therapy is (1) rest in bed, (2) local heat and (3) a liniment, (A.B.C. or Elliman's Embrocation).   This

simple (and quite natural) scheme works admirably in many cases, and possibly the fact that the patient is not referred to hospital is in itself a valuable factor in preventing the development of neurotic symptoms.

The writer usually advises as follows :-

(1) In the acute stage, complete rest in bed with a pillow under the knees and a low pillow under the lumbar hollow. Local heat if desired, and if necessary aspirin or veganin is prescribed as an analgesic.

(2) When the pain eases - usually in 7 - 10 days time - Radiant Heat or Infra -red and gentle massage is commenced. As soon as possible, i.e. when there is no spontaneous pain, active exercises are commenced.   It is important to graduate them carefully, e.g.

1st Stage.

Lying on back, (1) Ankle and knee exercises.

(2) Lifting one leg.

(3) Arm exercises.

2nd Stage.

Lying on back, (1) Lifting both legs.

(2) Raising head.
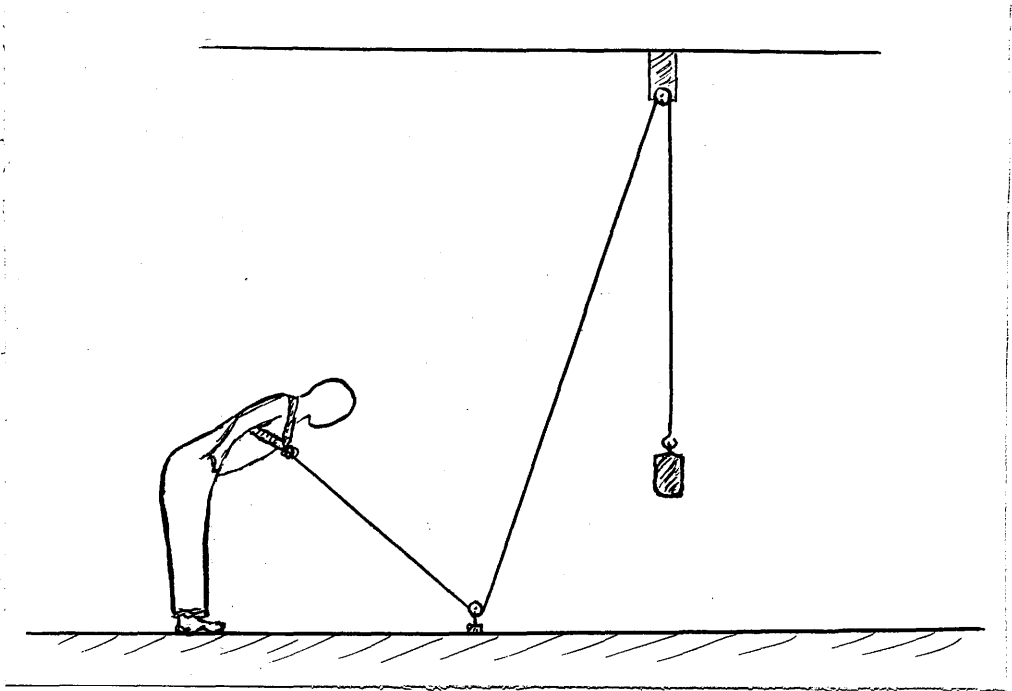
(3) Raising trunk.

3rd Stage.

Lying prone, (1) Lifting one leg.

(2) Lifting both legs.

(3) Lifting both legs and head, i.e.arching.

4th Stage.   (1) Graduated pulley R. E. (with increasing
              weights) for spinal muscles.(See Fig. 13).

5th Stage.   (1) Rehabilitation - hard and arduous
              exercises.

              (2) Games etc.

FIG. 13.

Remedial Back Exercises using Nicoll's Harness
and Pulleys.

This scheme of treatment in the vast majority of cases
gives gratifying results.

The injection of novocain (10 to 50 c.c. of $\frac{1}{2}\%$) is a
valuable procedure in certain cases.   If a case of myo-fascial
injury makes good progress, but a local tender area is
persistent, as is often found in gluteus maximus strains,
then novocain injection is of great value.   The injection
must be done with care and discrimation.   The technique
advocated consists in (1) an epidermal novocain wheal is
raised, using a fine hypodermic needle, (2) then, using a

larger needle (serum type), the point is pushed onwards until the patient states that the needle is touching the tender point; 5 - 10 c.c. are then injected, (3) the needle is withdrawn slightly and advanced again and a further 5 - 10 c.c. injected above the tender area.   This is repeated until the whole area has been treated, and until no local tenderness remains.   If the pain is not relieved, the diagnosis should be reconsidered.   (Ref. 15).

If relief is obtained, then active exercises are recommenced.   Occasionally a second or third injection is necessary.

Manipulation of the spine is occasionally necessary, especially in sacro-spinalis strains.   Before carrying out this manoeuvre, one must be satisfied that there is no evidence of disk prolapse.   Hence total scoliosis must be looked on as a contra-indication.   The type of case where manipulation is used is as follows :- (1) A neglected case with adhesion formation, (2) A resistant case of sacro-spinalis strain where, after physiotherapy and novocain injection have failed, there is evidence of local adhesion formation. The technique adopted is that of Bankart.   (Ref. 16).

(2) Sprains of Inter-spinous Ligament are rare (3 out of 52), but the cases studied have been very slow to respond to treatment.   The extraordinary feature of these is that a rapid and full recovery of movement was obtained but pain persisted.   This pain is uninfluenced by rest, physiotherapy or novocain injection, and in one case - not under the author's

care - the ligament was divided without relief.   There was
no evidence that the disk was injured and the writer cannot
explain why such cases are so troublesome.   One case has
been observed for over two years, and there is still
considerable pain, although the patient is quite well
otherwise.   It is reasonable to suggest that an arthrodesis
of the affected segments would be preferable to such chronic
disabling pain, but so far this has not been carried out.
(3) Disk Injuries.   In an early case, if one can be
reasonably certain of the diagnosis, e.g. where there are
pain, severe and persistent lumbar spasm, total scoliosis,
positive straight leg lifting test and sciatic pain, then
the spine should be immobilized in a plaster jacket, without
hyperextension, for a period of 8 - 10 weeks.   (Ref. 13).

In most cases the diagnosis will not be definite, and
probably a period of weeks will elapse before one feels that
the case is not a simple myo-fascial strain.   This will be
suggested by (1) persistent lumbar spasm , (2) persistent
total scoliosis and (3) perhaps development of sciatic pain.
Again, in this type of case, the spine should be immobilized
by means of a plaster jacket for 8 - 10 weeks.

In those cases that have relapsed after treatment, or
where conservative treatment has been ineffective, the
question of operation must be raised.   X-ray investigation
may show a narrowing of the intervertebral space, but
generally no help is obtained from a straight x-ray.

Lipiodal myelography has been used extensively in

diagnosis, but many writers point out that arachnoiditis is a complication to be feared, and therefore the tendency appears to be to rely on clinical investigation alone. (Ref. 11, 14, 17 & 19). Neurological examination is not helpful, but loss of the ankle-jerk may be found and there may be anaesthesia of the outer side of the foot and sole. The knee-jerk is not affected.

Operation consists in performing a formal laminectomy, or a hemi-laminectomy, so far as to expose the vertebral canal between the 5th lumbar and the sacrum. The disk between the 5th lumbar vertebra and the sacrum is most frequently affected, and the next most frequent is that between the 4th and 5th lumbar vertebrae; together they constitute 92% of all disk lesions. (Ref. 19). If a portion of disk is lying freely in the canal, it is removed: if the disk is prolapsing, but is still attached, that portion is removed. Dandy actually curettes the disk. Some surgeons recommend an immediate arthrodesis. Watson Jones (Ref. 11) states that if an articulation has been damaged or removed, arthrodesis should be performed. Burns and Young (Ref. 14), however do not favour arthrodesis. Dandy (Ref. 18) states that arthrodesis is only necessary if there is an associated spondylolisthesis or defective 5th lumbar vertebra.

(6) Acute Haemorrhage into a bursa - traumatic. This condition is seen most frequently in the olecranon bursa. The history is simple - a miner, shovelling or using a pick, knocks his elbow against a prop or a girder and on inspecting

the site of the injury is astonished to find a swelling about
the size of a walnut.   Presumably the injury leads to the
rupture of a vessel in the wall of the sac and blood is
poured out rapidly into the bursa.   (See Fig. 14).

Clinical features.   There is a tense swelling in the position
of the olecranon bursa.   The swelling is fluctuant and shows
very little tenderness.   There is no surrounding inflammation
as in an acute septic bursitis.

Treatment.   The simplest and most effective treatment is
aspiration of the blood from the bursa and the application
of a firm bandage.   Occasionally a second aspiration may
be required.   Sepsis may supervene and the features then
become typical of acute pyogenic bursitis.

FIG. 14.
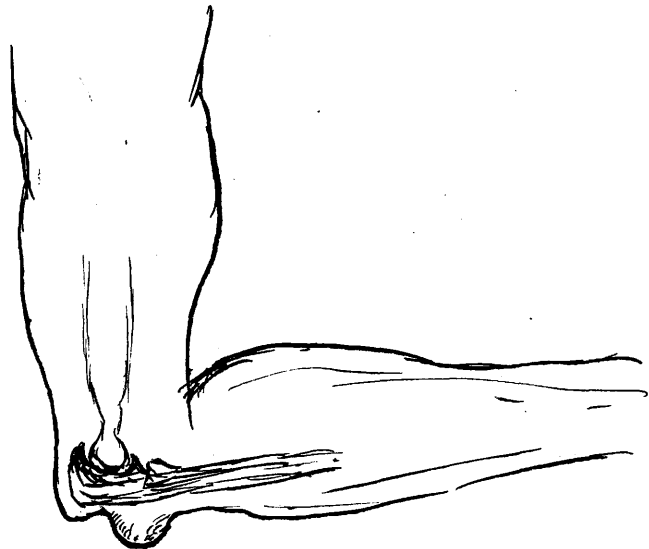
.Showing the appearance of an Olecranon Bursa
distended with blood.

(B) Other Accidents.

The variety of other accidents is such as to make classification difficult. From the point of view of simplicity, they will be considered on a regional basis.

1. Scalp.

Contusions and lacerations are very frequent and in most cases are caused by falls of coal or stone. Contusions need little further discussion, but where there is extensive extravasation of blood, an x-ray examination of the skull should not be omitted.

Lacerations. These vary from trivial injuries to most gross lacerations. In one recent case, the scalp was torn from ear to ear, and severe haemorrhage caused anxiety. It is well known that the scalp heals rapidly, but, as a general rule, in all extensive lacerations of the flap type, after suture, a drain should be left in place for 24 - 48 hours.

Concussion likewise is a common accident. The cases usually are of a mild type, and no doubt the introduction of safety helmets has helped to reduce the toll of the more severe head injuries. It is the writer's practice to admit all concussion cases for observation. In the common mild type with a period of unconsciousness ranging from a few seconds to 30 minutes, no special treatment is given. The patient is placed in a side-room on a pillowless bed, and the room is darkened. The bowels are kept open with a little Epsom Salts each morning. The important thing is careful observation of the temperature, pulse and respirations, and of the patients mental faculties. Headache is treated

by continued mental and physical rest, and rectal Hypertonic
Mag. Sulph. Solution.

This scheme of observation and therapy on the whole,
gives satisfactory results, and post-concussional symptoms
are not frequent.   The most common trouble in the
convalescent stage is - headache brought on by stooping,
and, unfortunately from the point of view of the miner, is
very serious: practically all colliery jobs entail stooping.

Complications of head injuries e.g. epilepsy, focal
paralysis, etc. are not treated by the writer.   These cases
are transferred to the care of a neurological surgeon.

Severe Head Injuries, compound fractures etc. are not
discussed, as these cases are usually transferred to the
care of a neurological surgeon.

2. Face.

(a) Contusions and lacerations.   Shot -firing injuries
have already been discussed (p. 24) and it was there mentioned
that ectropion may follow as a complication of such an injury.

Simple contusion is seen frequently and it is important
to bear in mind the possibility of underlying fracture, e.g.
malar bone.

Lacerations, likewise, are met with commonly and call
for no special comment other than the importance of removing
all particles of coal or stone.   In closing a laceration
of the face, the vertical mattress suture, using fine silk
worm gut or horse hair has been found very effective.

(b) _Fracture of the Nose._   This fracture is met with rather frequently.   There is no special type of violence responsible but the following histories are frequent :-

    1. A prop "jumping out", strikes the nose,

    2. The miner is knocked flat by a fall and his nose is impinged violently on the ground.

Clinical Features.   Epistaxis is met with in all cases and considerable swelling of the soft tissues on either side of the nose is the rule.   In the writer's experience the so-called lateral impaction fracture is the common type, one nasal bone being driven under the anterior edge of the other.

Treatment.   Reduction should be effected within 24 to 48 hours and the most useful instrument is the little finger, or a fine pressure forceps covered with rubber.   The instrument is introduced through the nostril and the depressed fragment elevated and pressure applied on the outer side of the nose over the other fragment.   Usually reduction is stable and no splintage is necessary.

    (c) Fracture of the Malar Bone.   This fracture is seen occasionally in miners.   The diagnosis should be arrived at clinically in the first instance and confirmed by x-ray. The deformity,if allowed to persist, is an ugly one and every effort should be made to reduce the fracture.

Treatment.   It may be possible to reduce the fracture by inserting a lever through the skin of the temporal fossa under the malar bone.   (Gillie's method, Ref. 26).   This method should be attempted in all early cases.   If delay

occurs, through doubt as to diagnosis, or to great swelling hiding the deformity, then the Canine Fossa approach is recommended.   This approach is much easier than would appear from reading a description of the operation, and the writer's experience in the few cases submitted to this operation has been reassuring.   Swelling of the face, after operation, is alarming for 24 hours, but it rapidly subsides.

In one case seen by the author, diplopia was present; and it is unfortunate that this case was not operated on, as Ungley and Sugget (Ref. 21) had successes in three such cases, the diplopia clearing up completely.

FIG. 15.

(Site of
(
(Fracture.

Fracture of Zygomatic Arch.

(d) Jaws, Fracture of Maxilla and Mandible. These fractures are not frequent, but when they do occur treatment is controlled by a dentist. The writer has been fortunate in having the services of a dentist skilled in this work. It is not proposed therefore to discuss these fractures further.

(e) Neck. Injuries of the neck are not frequent. Contusions are rare, but one case seen recently was of considerable interest on account of the extraordinary swelling that followed. Despite the great swelling, there was no clinical evidence of venous obstruction.

Fracture of the Cervical Spine. This is considered under Fractures of Spine.

3. Injuries of Arm (excluding hand).

(a) Contusions and Lacerations. Contusions and lacerations of varied form and type are commonly met with. The crush injury of the forearm has already been discussed on Page 27, under the heading "Conveyor Accidents".

Contusions of the Shoulder Joint are of considerable importance, especially when the subject is an elderly miner. In these cases, whether the blow is applied directly to the shoulder, or is transmitted up the arm, the result is apt to be much more serious than one would anticipate.

Clinical Examination. The arm is held to the side and no attempt is made to use it. There may, or may not, be diffuse swelling. Passive movement of the joint is resisted and the entire joint capsule is tender. X-ray examination reveals no fracture. If the patient is seen several days after the accident, a common complaint is that the joint aches in bed

at night and that it is impossible to lie on the affected side.

Treatment.   It is usually taught that the proper treatment of this condition is to institute active exercises, but in the writer's experience, so long as the patient complains of aching at night, and so long as there is diffuse shoulder joint tenderness, then such treatment is valueless.   The shoulder joint should be put at rest either on an abduction frame (not well tolerated in elderly miners) or simply on a St. John sling under the clothes.   Three weeks rest or more is often necessary before the tenderness and aching subside. When this stage is reached then graduated active exercises are commenced.   Passive stretching is mentioned only to be condemned.   The masseuses handling such cases must appreciate that the lesion is a serious one and treatment must be gentle yet progressive.   In the early stages of active movement, manipulation under anaesthesia is of very doubtful value. Considerable stress must be laid on the recovery of external rotation movements as a preliminary to abduction exercises.

The condition, if left untreated, is apt to drift into that vague group of diseases variously known as peri-arthritis of the shoulder, adhesive capsulitis or frozen shoulder. (Ref. 22).   When this stage is reached, one is confronted with a most difficult orthopaedic problem; but again reliance must be placed on persistent active exercises rather than passive stretching, in mobilizing the joint.   If, at this stage, it is clearly seen that movement is not increasing in range from week to week, then manipulation should be done with great care, as there is a great danger of fracturing the neck

of the humerus.   Probably it is better to carry out two, or even three, manipulations at intervals, than to attempt too much at one session.   After each manipulation active exercises are continued, but again, passive stretching is absolutely forbidden.   In most cases, by these methods, a good recovery can be effected in time.

(b) Fractures and Dislocations of Arm Bones and Shoulder Girdle.   Fractures of the arm bones are uncommon colliery accidents and out of 2,533 accidents occurring in one year only 16 of these were met with.

(1) Clavicle.   This is a rare colliery fracture and calls for no special comment.

(2) Acromio-clavicular Dislocation is seen occasionally in the younger miners.   The clinical features are well known and do not need description.   Treatment is by strapping according to the method of Sir Robert Jones (Ref. 23). It must be stressed however,. how frequently this method miscarries by wrongful application of the strapping over the acromium process - an error which maintains the dislocation admirably!   The strapping must be carefully applied over the clavicle and around the olecranon and must be applied firmly.   The strapping should be of the ordinary adhesive type - not elastoplast.   The dislocation requires close watching during the whole period of treatment.

(3) Scapula.   Fractures of the scapula, whilst not common, are occasionally met with in those cases where a man has been buried by a fall.   The usual type of injury shows one or more fissure fractures of the body.   Displacement of

the fragments is always minimal.   No special treatment is

required other than supporting the arm in a sling.   Active

movements are commenced in 14 to 21 days.

(4) Humerus.   The commonest fracture met with is a fracture of

the shaft of the humerus caused by direct violence.   Contusion

of the musculo-spiral nerve is a common accompaniment.   These

fractures unite readily if immobilized in a long arm plaster

extending from the shoulder to the hand.   The drop-wrist is

treated expectantly and in the great majority of cases the

musculo-spiral nerve recovers in a period of 6 to 10 weeks.

In one case at present undergoing treatment the patient

sustained a pertrochanteric fracture of the femur and a

transverse fracture of the humerus with musculo-spiral paralysis.

Expectant treatment in this case was not successful.   The nerve

was explored and a hard neuroma was found.   Distal to the

neuroma, the nerve was attenuated over a distance of $\frac{1}{4}$" to a

thickness of about $\frac{1}{8}$".   About $1\frac{1}{2}$" of the nerve was resected

and by means of extensive mobilisation of the two ends, a

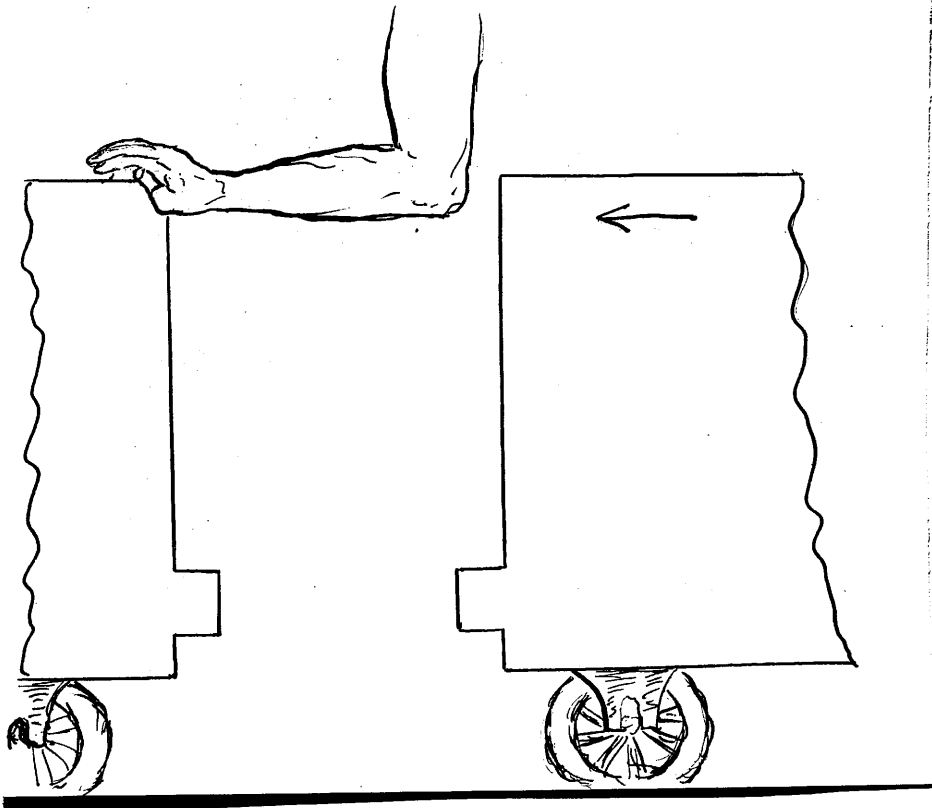satisfactory suture was effected.   (See Fig. 16).

FIG. 16.

Fracture

of Humerus.

(5) <u>Both Bones of Forearm</u>.   One type of fracture of both
bones is seen fairly frequently amongst the boys engaged in
handling the tubs.   The boy has his hand on the back of a
tub when a second tub approaches and strikes the elbow region.
(See Fig. 17).

<u>FIG. 17.</u>

The mechanism of production of the fracture
mentioned in Para. 5 above.

The result commonly is a greenstick fracture of both bones
in the lower third of the forearm.   The clinical features
of such an accident are typical and treatment consists of
manipulation of the fractures and the application of a
plaster cast from mid arm to knuckles.   The results are
excellent.   (See Figs. 18 & 19).

FIG. **18.**

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X-ray showing typical greenstick fracture of
both bones of forearm as met with in boys.

FIG. 19.

X-ray through plaster showing union after
manipulation and immobilization of such
a fracture.

A much more severe injury is the adult fracture.
This often takes the form of a fracture by direct violence
and may be compound.   Soft tissue injury is considerable
and the swelling may be extreme.   Volkmann's contracture
has been met with in one of these cases.

Treatment.   If compound the case is treated urgently.
A careful excision of the wound is performed, and, if
there is no undue tension, the wound is closed.   If it
appears unwise to close, then the wound is packed lightly
with vaseline gauze and a sterile dressing applied.   The
fractures are then manipulated and a long arm plaster
applied.   This manipulation is one of the most difficult
in all fracture work, as the bones are small and the
swelling is often great.   The plaster should always be
cut from the hand to 5" to 6" above the site of the
fracture.

If the fracture is a closed one, the problem is to
ensure accurate reduction.   This is often exceedingly
difficult, and even if successful, when the swelling
subsides, redisplacement may occur.   In such cases where
great difficulty is met with, an open reduction, with or
without plating should be carried out.

(6) Colles' Fracture is practically unknown as a colliery
accident.

4. Injuries of Hand and Wrist.

Hand injuries are so frequent and of such economic importance, that they must receive detailed consideration.

(a) Contusions.   All degrees and types of contusions are met with.   One of the most frequent is contusion of the terminal phalangeal region causing a sub-ungual haematoma.   This injury is exceedingly painful and disabling. Treatment as carried out by the patient sometimes takes the form of trephining the nail and allowing the blood to escape. This relieves the pain but there is a considerable danger of sepsis.   Many doctors advise prompt removal of the nail, but the author has found over many years experience that, if an elastoplast dressing is applied after sterilizing the finger end, the pain is soon relieved, and after 7 - 10 days, when the strapping is removed, the nail comes away very neatly, and without any pain.   Frequently there is an underlying fracture of the terminal phalanx.

Contusion of the hand requires no special comment, but on occasion the exudate is so great that the tension becomes extreme.   A case of this type, xax seen a few weeks ago, resulted in most gross swelling of the thenar and mid-palmar spaces.   The fingers and thumb were held in a flexed position, and tension blisters had developed.   It was considered necessary to evacuate the effused blood by incision and this produced rapid improvement.

Contusions of metacarpo-phalangeal and interphalangeal joints are also common and it is frequently noted that in

the case of the metacarpo-phalangeal joint of the thumb, prolonged disability may ensue. In these cases, where there is considerable effusion into the joint and marked joint tenderness, the finger should be immobilized on a splint in a position of flexion. It is particularly important never to immobilize a metacarpo-phalangeal joint in extension. The splint is retained for 2 to 3 weeks, or until such time as the swelling and tenderness disappear. Thereafter active exercises are instituted and these must be carried out with enthusiasm. The prognosis must always be guarded, as these cases may drag on for several months before full function is recovered.

(b) Lacerations. The term "laceration" is purposely chosen, as few colliery accidents are of the nature of "incised wounds". The wounds about to be discussed are caused by falling stone or coal and the result is a severely contused and ragged wound.

Lacerations of the wrist region are infrequent. They require the usual careful investigation with regard to injury to tendon and nerve. A very common injury is a laceration about 2" to 3" long extending along the side or the dorsum of a finger, or even almost surrounding the finger. Dust, fragments of coal or stone are ground into the sides of the wound, into the flexor tendon sheath and even into the tendon itself. Such an injury requires fine judgment in treatment and should not be tackled perfunctorily in the casualty department.

Treatment.   Assuming that there is no fracture, then
operation should be carried out as soon as possible.   A
general anaesthetic should be administered and the operation
carried out with the aid of a tourniquet.   It is often
stated that such a wound should be treated by excision and
suture, but it is very important to realize that excision
of a finger must be conservative, as there is
insufficient tissue available for radical measures.   Excision
therefore must be carefully performed, using a sharp scalpel;
if possible the tendon sheath should be cleansed with gauze,
but it is obvious that in some cases the damage is so gross
that whatever is done, the result will probably be poor.
The wound having been cleansed, sulphonamide is insufflated
and the wound is closed accurately with interrupted silk
worm gut sutures.   Buried catgut should be avoided.   If
tension is marked, then the wound should be left open, and
a light vaseline pack inserted.   (Ref. 24).   As soon as
the wound is granulating healthily a split skin graft should
be applied.   The stiches should be left in place for 12 to
14 days.   If the wound heals kindly, careful follow-up
treatment in the form of exercises should be commenced at once.
Handfield-Jones (Ref.) lays down ten rules for the treatment
of lacerations of the hand and the writer subscribes to these
rules.   But special emphasis must be placed on the danger
of tension: tension and sepsis in finger wounds are almost
synonymous terms.

       If the flexor tendon is divided where there is no sheath,

then primary suture may be carried out, provided there is
confidence as to the cleanliness of the wound.

If the tendon is cut within the sheath area, no
immediate suture should be done. The wound should be treated
primarily and after 6 - 8 weeks, a formal operation under
ideal surgical conditions should be undertaken.

As to how the tendon within the sheath area should
ultimately be sutured, the writer holds no strong views, as
experience of all methods so far has been very disappointing.
It is admitted that catgut, silk,fine metal sutures etc.
are all disappointing, as the tendon invariably becomes
adherent to the sheath. Recently Bunnel (Ref. 25)
has advocated the removal of both tendons from the sheath
and the replacement by a tendon graft from palmaris longus -
the graft being sutured to the F. Profundus & Sublimus Digitorum
outside the sheath and to the periosteum of the
base of the terminal phalanx also outside the sheath.

So far the writer has not attempted this method.

In one recent case of the author's, the flexor pollicis
longus was cut at the level of the proximal phalanx by a
falling stone. The wound was filthy and much stone was
ground into the tissues. The wound was excised and sutured,
but the tendon was left. Six weeks later a formal suture
was effected, but as usual, adhesion to the sheath led to
great disappointment. There was no movement of flexion at
the inter-phanangeal joint, the whole finger moving as one.
It was decided to explore the finger once more. When this
was done the flexor tendon and sheath were found buried in

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a dense scar.   The tendon had to be dissected out of the
adherent mass.   A piece of sterile cellophane was then
wrapped around the tendon and the wound closed.   Movement
was commenced on the 5th day, and from the beginning it was
obvious that there was a great improvement - the terminal
phalanx could be moved!   After removal of the stitches,
exercises were continued and the end result was estimated at
80% recovery.   The boy is back at his normal work as a
haulage hand.

One other case of a somewhat similar nature is at
present under treatment.   A youth sustained a dirty
laceration across the volar aspect ot the proximal inter-
phalangeal joint of the left index finger.   The tendon sheath
was cut, but the tendons were intact.

Primary treatment consisted in excision of the wound
and closure.   Healing occurred readily, but the finger
progressively stiffened.   Two months later, the patient was
referred to hospital by his doctor to have his finger
amputated, as it "stuck out and was always in the way".
The writed agreed, but after discussing the problem, it was
decided to make one attempt to restore function before
amputating.   At operation, the profundus tendon was found
widely adherent to the sheath and to the sublimus.   The
adhesions were divided and the profundus tendon cleared
from its insertion to the middle of the proximal phalanx.
The tendon was then wrapped round with sterile cellophane
and the skin wound accurately closed with interrupted sutures.
Active movements were started on the 3rd post-operation

day.   Now - three weeks after operation - he has regained about 50% of normal flexion movement at the proximal inter-phalangeal joint.

This case does not appear likely to be a complete success, but it is very encouraging, and cellophane seems to be the most satisfactory substance for preventing adhesion formation. Possibly, had the sublimus tendons been removed altogether, a better result would have followed!

The surgery of the flexor tendons in the fingers bristles with difficulties and it may be that we will never get perfect results: but these encouraging cases quoted suggest that methods will be found to yield a useful, if not normal, functioning digit.

Similar types of laceration caused by falls of stone or coal are met with in all parts of the hand, and the treatment outlined above is applicable to all these injuries.   In lacerations of the dorsum of the hand where there is skin loss, it is important to remember the excellent results obtained by the use of direct skin flaps.   The transference of a direct skin flap should not be carried out immediately unless one is certain that there is no infection.   It is sounder practice to delay the application of the skin flap until the raw area is surgically clean.   A skin flap from the abdominal wall is eminently suitable for covering such dorsal defects.   (Ref. 26).

Adherent scars following lacerations of the Hand.

Scars of this type are very liable to follow the gross lacerations sustained by miners.   On the dorsum of the hand

and in the palm, such scars are very disabling,
interfering with free movement of the extensor tendons,
and in the palm, leading to a contracture rather like
the position of the hand called "main d'accoucheur".
In such cases the question of excision of the scar and
replacement by skin flap should always be considered.
In one recent case the scar extended from the web of the
thumb along the radial side of the proximal phalanx of
the index finger.   This scar did not interfere with
movement, but the miner found that the handle of the shovel,
rubbing against the scar, repeatedly led to the scar
breaking down.   This case was treated by careful excision
and fixation of a skin flap from the abdominal wall.
The result in this case is all that could be desired.
Instead of a dense scar, there is now an area of healthy,
supple skin, with an excellent pad of subcutaneous
tissue.   (See Fig. 20).

FIG. 20.
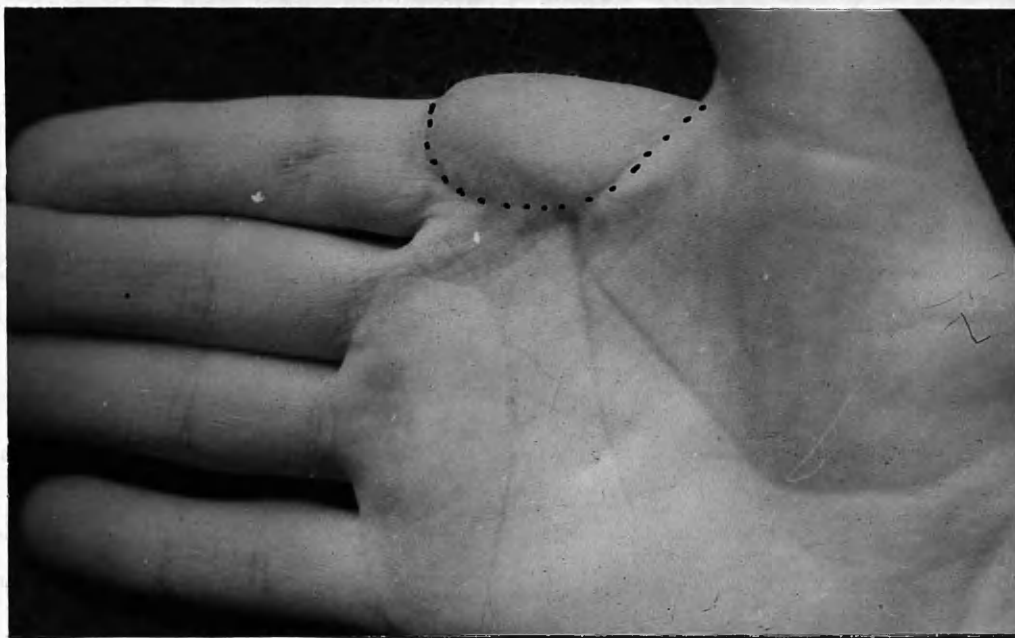
Showing result of pedicle graft after excision
of scar. (Graft indicated by dotted line).

In the case of the fingers proper, the writer has had
much less success with abdominal skin flaps, but several
cases of loss of tissue at the tip of the thumb have yielded
encouraging results.   Generally, in the case of fingers,
if the scar is linear, a careful excision will suffice.
Where there is a broad flat scar of the pulp of the terminal
phalanx, the best treatment is partial amputation.

If a laceration of the dorsum of the hand is associated
with loss of extensor tendon and scarring, the method
recommended by Cuthbert (Ref. 27) should be adopted.   He
advises (1) excision of the scar and replacement by pedicle
flap, (2) reconstruction of the tendon, using plantaris,
(3) the reconstructed tendon is threaded through the

subcutaneous tissue of the flap.   From reports published by Cuthbert the method is well worth trying.

Finally, it should never be forgotten that a well performed amputation of a finger is much more satisfactory than leaving a miner with a scarred stiff finger.

Amputation of Fingers.   In traumatic work textbook amputations are frequently out of the question.   The problem is to save as much of the finger as possible and to fashion a satisfactory stump with the available tissue.

(a) Terminal Phalanx.   The indications for amputation are :-

1. Complete loss of the soft tissue of the terminal phalanx,

2. Gross destruction of the soft tissues and bone. It must be noted that a comminuted fracture with destruction of the nail bed is not an absolute indication.   Conservative treatment should be adopted if possible.

The flap should be of volar origin and the scar should always be on the dorsum.   At times this cannot be managed and the risk of adherent tender scar must be taken.   The flap must never be tense, and in all cases should contain a pad of subcutaneous fat - a "bare" flap adherent to bone is useless for a miner.   It has been stated that a "good-looking" amputation is usually a good amputation and this is as true of fingers as of limbs.   The tight adherent flap is always tender and blue.   Great ingenuity may be needed in some of these cases.   The level of the bone section should, if possible, be such as to leave the insertion of the tendons

undisturbed.   A disarticulation through the interphalangeal joint is usually unsatisfactory: the stump is too cumbersome and is apt to catch against the adjacent fingers when flexing.

(b) Mid and Proximal Phalanges.   Indications for amputation:-

1. Complete mutilation of the finger,
2. Compound fracture, with section of flexor tendon and a gross soft tissue injury,
3. A gross soft tissue injury with loss of blood and nerve supply to the digit.

In amputations through the mid-phalanx, the proximal half of the bone should be retained.   The remarks about amputation of a distal phalanx apply equally to mid-phalanx. The flexor and extensor tendons should be sutured carefully together over the end of the sectioned bone.

Proximal phalangeal amputations, to be of any value to a manual labourer, must be as long as possible, so that the maximum "hook" effect can be obtained.   There is no point in leaving a miner with a $\frac{1}{4}$" of bone: such a stump serves no useful purpose.   In the case of the index finger, an amputation through the proximal phalanx is best avoided. Disarticulation at the metacarpo-phalangeal joint is, unfortunately, often required.   The amputation at this site is a good one, if well performed.

The writer has used for several years a relatively unknown method (at least unknown in the North East of England) - Chiene's method.   (Ref. 28).   This method is conditional on there being an ample supply of volar skin;

and if such is available the result is most satisfactory.
The volar flap produces an excellent, thick, soft pad, and
many miners have testified to its virtues,

Traumatic cases do not always lend themselves to Chiene's
method, and an ordinary racquet incision may have to be used.
The results are seldom quite so good and the scar is apt to
become sensitive.

One point requires emphasis - the importance of leaving
the head of the metacarpal.   The temptation to remove the
head (for aesthetic reasons) should be resisted: it is not
always appreciated how the hand is weakened by this removal.
(c) Thumb.   It is a surgical axiom that the thumb should
never be amputated, without obtaining a second opinion.   If
it is decided that there is no other form of treatment, then
every fragment must be saved.   A lost thumb can never be
restored, despite the ingenuity of surgeons.   The technique
is similar to amputations of the fingers.

The writer has at present a patient under his care
whose thumb was completely removed by a sharp tool.   He was
left with about $\frac{1}{2}$ " of proximal phalanx only.   It was
decided to make an attempt to elongate the thumb.   A
tubular Gillie's graft was raised from the abdominal wall
and the scar of the stump excised and sutured to the tube
graft.   It is hoped later to insert a bone graft to provide
a thumb with a solitary movable phalanx about $1\frac{1}{4}$" to $1\frac{1}{2}$"
long.   Cuthbert(Ref.27) reports a case where a joint from
the 4th toe was transplanted into a reconstructed thumb.
The result was encouraging.

Fractures and Dislocations of the Hand.   Fractures of the

fingers are exceedingly common, and a high proportion **are**

compound.   It is not easy in these injuries to obtain a

first class result as (1) the fractures are in almost all

cases compound from without in, (2) the violence is great

and (3) the skin wound is usually gross, with contusion of

the surrounding skin and consequently great liability to

break down.

(a) Fractures of Terminal Phalanx.

    Fig. 21 is an x-ray of a typical compound fracture

of a terminal phalanx.

FIG. 21.

    Usually the phalanx is comminuted and the fracture is

almost always compound.   The usual picture is this:-

(1) A subungual haematoma, (2) A ragged bursting laceration

on either side of the nail and (3) Swelling of the pulp.
If the nail is removed(not always a necessary or beneficial
treatment), a laceration across the nail bed is often found
and this laceration communicates with the fracture.   Fig. 22
is a diagrammatic representation of this.

<div align="center"><u>FIG. 22.</u></div>
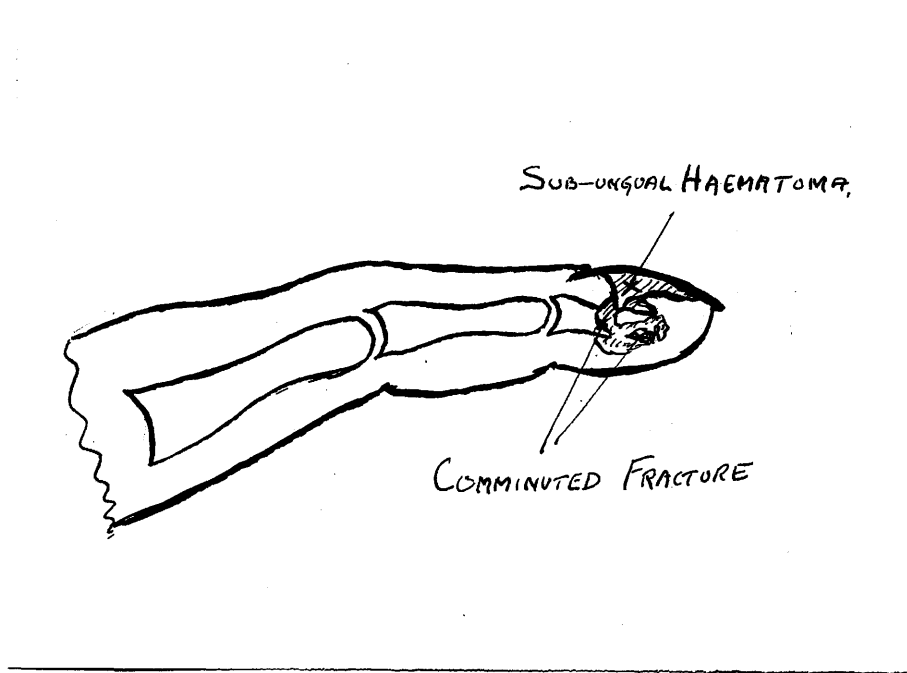
Obviously, if the nail is removed, a direct communication
exists between the fracture and the air.   This thought has
prompted the author to be conservative in treatment.   The
finger is carefully cleansed with soap and water, and then
an antiseptic is applied.   In many cases without great
deformity, it is unnecessary to splint the finger.   The
writer often applies (1) Sulphanilamide tulle dressing and
(2) A firm elastoplast covering.

Where there is displacement of the phalanx, this is

corrected under gas and oxygen, or nerve block anaesthesia,
and the finger immobilized in a small plaster splint.
(See Fig. 23).

FIG. 23.
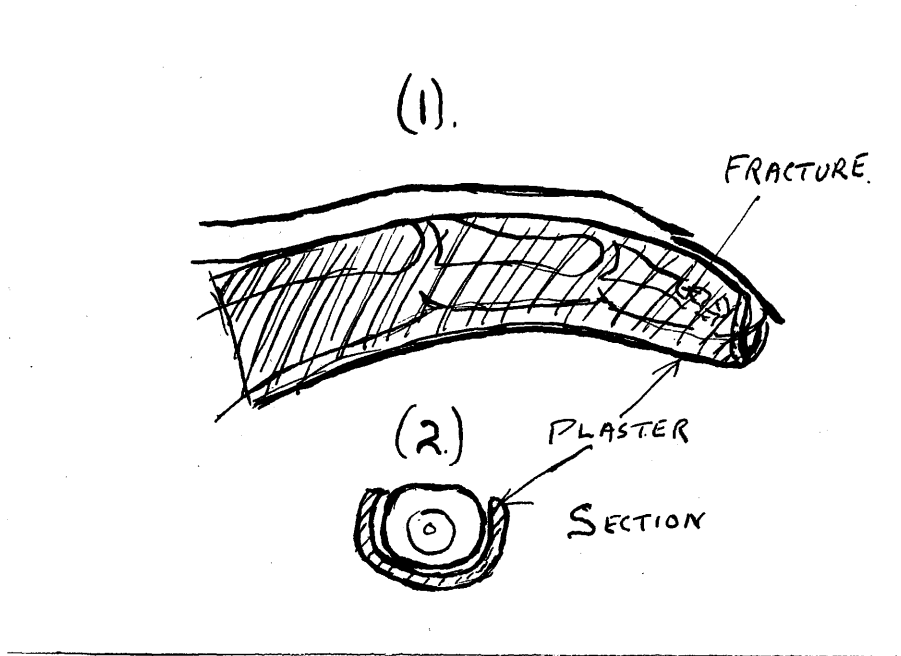
(b) Fractures of Middle Phalanx.

This may take the form of (1) a fissure fracture with
no displacement or (2) a short oblique fracture with the
usual volar angulation.

Type (1) requires no more splinting than a firm covering
of elastoplast.   Check x-rays must be taken thereafter.

Type (2) must be treated in flexion as for a fracture
of the proximal phalanx (q.v.).

FIG. 24.

X-ray showing fracture of Middle Phalanx
of Index Finger.

(c) Fractures of the Proximal Phalanx.

This common and important fracture is often compound.
The fracture is usually nearer the base than the head, and
in practically all cases there is volar angulation.   This
is caused in part by the force causing the fracture and in
part by the spasm of the interosseous and lumbrical muscles.
(Ref. 29).   Certainly the small muscles maintain the deformity.
Treatment.   If compound, the wound must receive immediate
attention.   Under general anaesthesia, a careful excision
is performed.   If the flexor or extensor tendon is cut,
repair should not be attempted at this stage.   The wound
is closed, or packed lightly, according to the tension of
the tissues.   A finger splint of the Bohler pattern, or of
narrow Cramer wire, is then incorporated in a forearm plaster
and the splint bent to the required shape.   The finger is

then applied to the splint and fixed with adhesive. If
the fracture is oblique and the tendency to redisplacement
marked, it may be necessary to pass a suture of stainless
steel wire through the pulp of the terminal phalanx and fix
the other end to the free end of the splint. It is most
important that the metacarpo-phalangeal joint should be
flexed to 45°. The diagram shows more clearly than words
how the splint is fixed. (See Fig. 25).

FIG. 25.
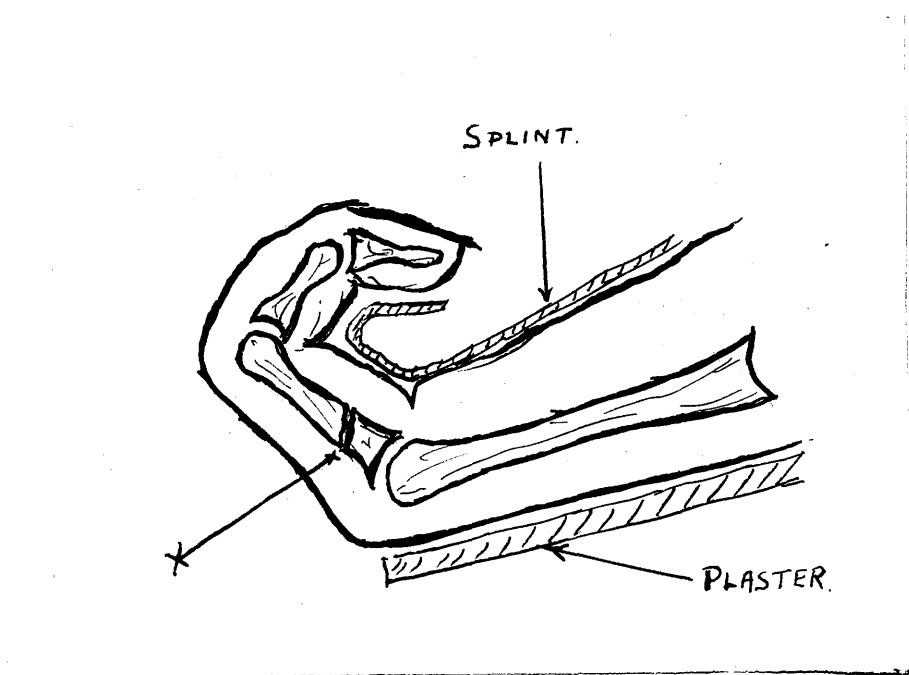
This method gives excellent results and in probably 80%
of cases there is no necessity to transfix the pulp. It is
generally stated that the splint should be left in place for
3 - 4 weeks. The writer favours 2 - 3 weeks, as usually at
the end of that period the fracture is sufficiently

consolidated to allow of early active exercises.

Where the fracture is compound and there is an associated cut flexor tendon, the results are extremely poor. Many surgeons recommend immediate amputation for this type of injury.

Thumb Injuries.

Fractures of the terminal and proximal phalanges are treated in a similar way to those fractures affecting the the fingers.   (See Figs. 26, 27, 28.).

FIG. 26.

Metacarpal Fractures.   FIG. 27.

FIG. 28.

Metacarpal Fractures.

These fractures are relatively common. The fracture
of the neck is not so frequently seen as the shaft fracture.
In Neck Fractures reduction, by applying pressure in the line
of the proximal phalanx held at right angles to the
metacarpal, is effective and this is maintained by means of
a plaster cast. Sometimes very considerable force has to be
used to correct the angulation. (See Fig. 29).

Fig. 29.
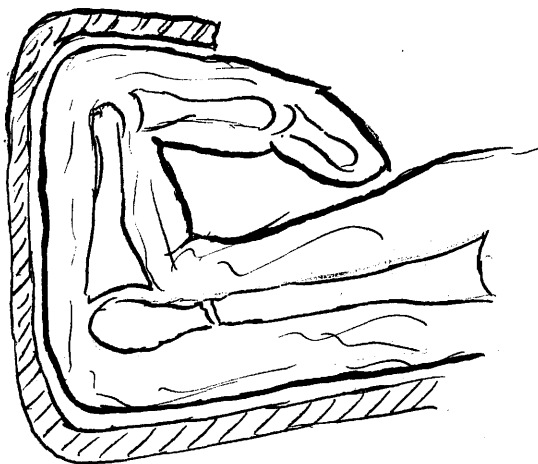
Fracture of the Shaft is a more common accident. Any
angulation must be carefully corrected and maintained by a
moulded plaster cast. It is not often necessary to apply
traction to a finger to prevent over-riding of an oblique
fracture of a metacarpal, but where it has to be done, the
simplest method is to incorporate a finger splint in a

forearm plaster and fix the extended finger to the splint.
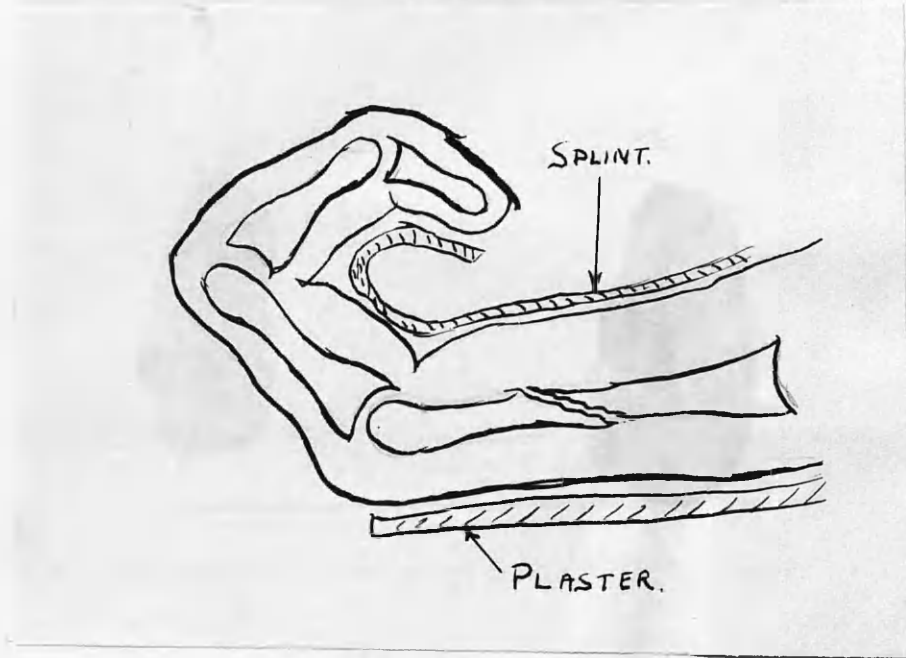(See Fig. 30, 31, 32, 33).

FIG. 30.

FIG. 31.

Fracture of base of Metacarpal of Thumb.

FIG. 32.

Oblique fracture of second metacarpal.

FIG. 33.

Bennet's Fracture of Metacarpal of Thumb.

Compound fractures are troublesome injuries, and many result in adhesions of the extensor tendons.   If there is a dense adherent scar, this should be excised and a direct pedicle graft carried out.

Fractures of the Carpus.

Scaphoid fractures are met with occasionally. Treatment calls for careful immobilization for 8 - 10 weeks. A further x-ray examination is carried out and if there is no x-ray evidence of union, immobilization must be continued until radiographic union is obtained.

In cases of delayed union where the patient wishes to return to light work, Farquharson's splint (Ref. 30) is of great value, and is recommended.

Other fractures and dislocations of the carpus are rare. Two cases of perilunar dislocation of the carpus have been seen and one was associated with a fracture of the scaphoid - here reduction was easily effected, but union of the scaphoid was exceedingly slow.

A remarkable case, and one that demonstrates to a degree the complexities of traumatic surgery, is at present under treatment.

The patient - a youth of 25 - had a very severe crush of the L. hand.   On admission, the hand was grossly swollen. There were four bursting lacerations - one across the dorsum of the wrist, two in the palm with bulging muscle, and a fourth on the ulnar side of the palm.   X-ray examination (See Fig. 34) revealed a most extraordinary injury :-

(1) A comminuted fracture of the 4th metacarpal,

(2) A radial dislocation of the bases of the 2nd and

3rd metacarpals,

(3) An oblique fracture of the base of the thumb

metacarpal, and

(4) A dislocation of the scaphoid. In the x-ray the

scaphoid is seen end-on.

Operation was carried out within three hours of the
accident happening. The wounds were excised and loosely
sutured: a Brock's Pin was inserted through the pulp of
the thumb and one through the pulp of the 4th finger.
Traction was applied to these pins and the scaphoid was
manipulated and reduced easily. The two displaced
metacarpals were reduced by direct pressure. A forearm
plaster was then applied, a "banjo" outrigger fitted and
the Brock's Pin attached to the outrigger. X-ray (See
Fig. 35) showed that all the dislocations and fractures
were in excellent position with the exception of the base
of the thumb metacarpal. Since operation excellent
progress has been made, and the finger movement is
improving steadly. It may be necessary later to arthrodese
the base of the first metacarpal to the trapezium.
Reproductions of the pre-operation and post-operation x-rays
are shown in Figs. 34 and 35.

FIG. 34.

Pre-operation X-ray.

FIG. 35.

X-ray after manipulation.

Kienbock's Disease of the semilunar bone is seen from time
to time.   Often there is a history of repeated traumata to
the hand and wrist, but the relationship is not convincing,
as most miners suffer trauma to the hand each day they are
at work, yet only a very small percentage develop Kienbock's
disease.

Treatment by immobilization is usually ineffective, and
if there is severe pain and spasm, arthrodesis of the wrist
is probably the best solution to the problem.   The
functional disability after arthrodesis of a wrist joint is
very slight.   One of the author's cases (a particularly
tough labourer) has returned to heavy labouring and
apparently suffers no handicap.

Brittain's method is favoured, and results are
gratifying (Ref. 31).

5. Injuries to the Leg and Foot.
(a) Contusions of the lower limb are extremely common mine
accidents, and many are of considerable surgical interest.

Thigh contusions are of varying severity, and mostly
they are very disabling.   Falls of stone and coal, or heavy
props etc., are the usual cause, and the result may be in
one case little more than a simple bruise, or in another a
severe contusion with rupture of muscle and great swelling.
The outpouring of blood is sometimes gross and the thigh
then presents an extraordinary appearance.   Such injuries,
being associated with severe pain and considerable loss of
fluid from the circulation, are productive of shock.   A

frequent late development is an encysted collection of serous
fluid.   The rectus femoris is the most frequently damaged
muscle, but it is not easy to be certain in the early stages
that a muscle has been severed.   A rise of temperature to
100° or 101° F. is frequent 24 - 48 hours after the accident.
Treatment.   Rest with the knee flexed over a pillow is the
most useful measure in the acute stage - local applications -
cold compresses or a compress of lead and opium with firm
bandaging may be used.   Morphia is often necessary for
relief of pain.   After 7 - 10 days, when the pain has eased,
active exercises should be commenced.   A noticeable feature
is the residual induration of the muscles, and infra red
and gentle massage is of great value at this stage, but
active muscle contraction must not be neglected.
Complications are frequent :-
(1) Haematoma formation necessitates aspiration, and firm
bandaging,
(2) Infection of a haematoma is met with occasionally if
there is a septic focus elsewhere.   If such occurs, the
infected haematoma must be treated as an abscess, and
drained freely,
(3) Myositis Ossificans is often seen as a late complication.
The patient complains of a hard swelling in the thigh at the
site of the injury.   If no history of injury is obtained,
a diagnosis of sarcoma may be made.   X-ray shows in an early
case, a mottled, irregular shadow close to the femur, but
no destruction of bone, and no "sun-ray" appearance.
In the later stage the x-ray picture shows a more dense and

more clearly defined shadow.   Finally - months after the
injury - the bone consolidates and forms a well defined
"osteoma".   (See Fig. 36).

FIG. 36.

Traumatic Myositis Ossificans.

The treatment differs according to the stage of development.
In the early stage with "fluffy" x-ray appearance, no surgery
must be undertaken.   The patient should be advised "to take
things easily".   Absolute rest, as Watson Jones shows, is not
necessary.   (Ref. 11).   In the next stage, i.e. when the
shadow is well defined and the margin is clear, removal of the
bony mass may be performed: but it is not always necessary
e.g. if the newly formed bone is close to the femur and is not
interfering with movement.   In the final stage, the

"osteoma" may be removed if prominent and if its presence
is a psychological or mechanical hindrance to the patient's
recovery.

(4) Rupture of the belly of the Rectus Femoris Muscle.

Correctly speaking, this is not a·complication, but the
diagnosis is not usually made until such time as the
swelling has subsided, and exercises have been started.
Then the masseuse notices a swelling - usually of the
straight head of the Rectus Femoris - appearing when
active contraction takes place.   Probably most of these
cases are of the nature of incomplete ruptures, and
clinically, there is little loss of muscle power.   The
writer has always adopted a conservative attitude and
recovery in all cases has been gratifying.   This
attitude was reinforced recently on seeing an unfortunate
man who had had a ruptured rectus.   An enthusiastic
surgeon had exposed the muscle by means of a huge U flap,
sutured the muscle and immobilized the limb in a spica
plaster.   Unfortunately the plaster was kept on for 10
weeks and the result - anatomically perfect - was,
functionally, dreadful.   Despite most energetic treatment,
flexion of the knee never reached 80°.

Knee Contusions - see under Knee Joint (p. 86).
Leg and Foot Contusions.   There are no features calling for
special comment here, other than the development of post-
traumatic oedema.   This troublesome complication should be
anticipated by the surgeon, and an Unna's paste type bandage

applied from the base of the toes to the knee. The bandage does not interfere with exercise. The decision as to when to remove the supporting bandage is arrived at by asking the patient :- " Does the bandage feel tighter after walking about?" - if the patient answers "Yes", then the bandage should be left in place. As soon as the bandage is removed, simple contrast baths are of value in toning up the foot. If there is any tendency to Pes Planus, an inner raise on the sole of the shoe should be prescribed.

(b) Lacerations.

(1) Thigh lacerations are all potentially dangerous, especially if muscle is damaged. In such cases a thorough excision of the skin edges and all bruised muscle and fascia must be carried out. Buried catgut should be avoided if at all possible, but as haemostasis is important, this precept is not always practicable. If the laceration is of a deep and dangerous type, the limb ought to be immobilized in a Thomas' splint and elevation maintained. Such wounds should be treated by the open method. (Ref. 9). A prophylactic course of a sulphonamide, and prophylactic Anti Tetanic Serum and Anti Gas Gangrene Serum should be administered. Later, secondary suture can be performed.

(2) Lacerations of the Leg and Foot. Shin lacerations are very frequent and, as everyone knows, very painful. Lacerations gape widely and often lay the tibia bare. Treatment is carried out on the usual lines, but closure of the laceration after excision is difficult. Judicious relieving incisions

are very useful and will often allow of the tibia being
covered.

The Foot is well protected by the strong boot worn by miners,
and consequently any laceration is usually caused by great
violence such as rips the boot. A coal-cutter pick
occasionally rips a boot, causing a horrible laceration of
skin, fascia, tendons and sometimes bone. It is a type of
wound fraught with difficulties and dangers, and calls for
great skill in treatment. The primary duty is to treat
the patient for shock. Thereafter the wound must be
carefully excised and all shredded fascia and tendons removed.
The skin may be torn in such a way as to leave a flap with
uncertain blood supply - a not infrequent type - and one is
often left in doubt as to the treatment of such a flap.
(See Fig. 37).

FIG. 37.

Generally, if the skin is not obviously dead, the flap should
be left, with perhaps one or two loose stitches placed so as to
hold it in place.   Sulphanilamide is insufflated and a
dressing of vaseline gauze or Tulle Gras applied.   The foot
is immobilized in a light plaster, and placed in a Bohler-Braun
splint.   AntiTetanic Serum and Anti Gas Gangrene Serum are
given as usual, and a course of sulphonamide commenced.
The first dressing should be performed in the theatre about
the 7th - 10th day.   By then the fate of the flap is obvious
and an estimate can be made of future skin-grafting
requirements.   At this stage, it is an advantage, in a dorsal
wound, to apply a posterior splint or plaster slab, so as
to enable one to prepare the site for skin-grafting.   When
the site is ready, a thick Thiersch graft may be applied,
or a pedicle graft from the opposite thigh.   (Ref.27).
Later reconstruction of tendons may be called for.   Such
a case obviously demands great patience and fortitude on
the part of patient and surgeon.

If sepsis ensues, and the patient is left with
a badly scarred, rigid and painful foot, and especially if
there are any sinuses from bone infection, then the question
of amputation should be considered.   There is no doubt
that a well performed amputation, with a good artificial
limb, is preferable to leaving a working man with a rigid,
inelastic, painful foot.   The writer has several men with
below-knee amputations working underground and managing
well; naturally these men cannot undertake facework -

filling etc. - but they are useful workmen, their morale has been preserved, and they feel that they are of some use in the community.

(c) Injuries to the Knee Joint.

The coal-mine and the football field vie with each other in producing knee injuries, and the surgeon working in a coal-field very soon realizes the tremendous importance to the miner of a stable, painless joint. All types of injuries are met with, from trifling bruises to comminuted intra-articular fractures. In this section, the soft tissue injuries only will be considered.

(1) Bruises and Contusions.

These are the commonest injuries. A falling stone strikes the knee over the suprapatellar pouch, or over the side of the joint. The injury is painful, and within a few hours an effusion is poured out. Rapid atrophy of the quadriceps follows. The injury responds well to treatment.

The knee is rested over a pillow, and a firm bandage applied over the joint, but it must not encroach on the thigh muscles. Provided other injuries (e.g. ligamentous strain etc.) are excluded, in 2 - 5 days active movements should be instituted. Faradic stimulation is of doubtful benefit as a muscle builder, but it often helps in getting a sluggish quadriceps once more into activity. If the effusion recurs, a firm crêpe bandage should be worn.

Occasionally one meets with a "sensitive " joint, i.e.

a joint where any return to activity leads to a further effusion. In such cases, the best principle is "go easily", and it is an advantage to commence with non-weightbearing exercises. Treatment should be graduated with great care, and vigorous rehabilitation is contra-indicated in the early stages of recovery.

Contusion of the knee in elderly miners is liable to lead to prolonged disabliity. X-ray examination of such joints often shows a degree of osteo-arthritis, and the blow appears to aggravate this. The knee stiffens, becomes painful and at times hot, and aches "like toothache". Such cases respond but poorly to any therapy. Probably, as in other contusions, the proper course to adopt is (1) Rest, (2) Graduated non-weightbearing exercises, (3) Graduated weightbearing. Despite most careful handling some joints get progressively worse, and the disability progresses. The writer remembers vividly a case seen about three years ago: an elderly miner (57 years) had a simple contusion of the knee joint. He was bow-legged, and x-ray showed a considerable degree of osteo-arthritic change. The reaction to the injury was most dramatic: the joint swelled up, there was local heat, marked muscle spasm and severe aching pain. The knee was rested, and more than two months elapsed before the acute symptoms subsided. Thereafter the joint, now more comfortable, became gradually stiffer, and he was finally left with a range of about 25°. There was no improvement with diligent exercise and physiotherapy.

Contusions of the outer side of the joint may lead to foot-drop, and this must always be looked for. None of the cases met with have required exploration of the nerve. Treatment with a splint to prevent muscle stretching, and Faradic stimulation of the muscles affected, leads to recovery in 5 - 10 weeks time. After active muscle contraction appears and the splint is removed, a spring, attached to the shoe to prevent the weight of the foot causing plantar flexion, is of great value, and can be worn until muscle power is normal.

(2) Ligamentous Injury.

(a) By far the most frequent injury of this type is a sprain of the medial ligament of the joint - the Tibial Collateral Ligament. The history is that the tibia has been forced into a position of abduction with reference to the femur. The medial side of the joint is opened up, and the medial ligament is made taut. The usual result is a sprain, i.e. rupture of a few fibres of the ligament at the femoral attachment. Clinically: There is well marked local tenderness, not in the joint line but over the femoral condyle. Forced abduction of the tibia causes pain at the point of tenderness. An effusion follows in 6 - 8 hours. Treatment consists of rest, firm bandaging with a crepe bandage, an inner raise of the sole of the shoe and early active quadriceps exercise.

When there is arthritis of the joint, response to treatment is slow.

The medial ligament may be sprained where it is attached to the medial cartilage, and in this case the diagnosis is not so straight forward. The point of tenderness is on the joint line, but further back than the usual point of cartilage tenderness. One is often in considerable doubt as to the presence of an associated tear of the cartilage, and in such a case the writer is in the habit of advising 4 - 7 days rest, with a firm bandage, and re-examination after that interval. Usually by then a more accurate and satisfactory examination can be effected and a diagnosis arrived at.

Rupture or Avulsion of the Medial Ligament is a much more severe injury. The ligament is detached completely from the femur, giving rise to severe pain and swelling, marked local tenderness and early onset of effusion. The characteristic sign is, of course, the lateral instability of the joint. The tibia can be abducted on the femur through a range of $10^{\circ} - 20^{\circ}$. X-ray examination made with the knee in forced knock-knee position is very striking.

Treatment consists of prolonged immobilization - 8 - 10 weeks - in a plaster extending from the ankle to the groin. A check x-ray must be taken after the plaster is applied to ensure satisfactory position. While the plaster is in place, the patient can walk about and carry out active exercises. On removal of the splint, active quadriceps drill is commenced at once and the patient is advised to persevere until the tone and strength of the muscle equals

that of the normal side.

(b) <u>External Lateral Ligament</u> sprains are by no means common.
<u>Diagnosis</u> is simple provided a clear history is obtained.
In these cases x-ray examination must always be carried out,
as avulsion of a flake of bone from the head of the fibula
is met with occasionally.

In simple sprains immobilization is not necessary, and
treatment, as indicated for the medial **ligament,** but without
the inner sole raise, is satisfactory.

Where there is rupture of the ligament from the bony
attachment, or if a flake of the head of the fibula is
avulsed, the leg must be immobilized for 8 - 10 weeks.
It is important to exclude a traction injury of the External
Popliteal Nerve.   (Ref. 32, 33).

(c) <u>Cruciate Ligament Injury.</u>

Despite the frequency of knee injuries in mines, the
writer has not seen many cases of cruciate injury. In one case
of avulsion of the medial ligament, the knee could be hyper-
extended by almost 10° compared with its fellow.   There was a
haemarthrosis present.   This was aspirated and the knee
was immobilized in plaster for 12 weeks.   The plaster was
applied with the knee flexed to relax the anterior cruciate.
When the plaster was removed, active exercises were commenced
and the end result was satisfactory - the Tibial Collateral
healed perfectly and no lateral instability was demonstrable,
but there was slight persistent hyper-extension.   Despite

this lengthening, or laxity, of the anterior cruciate, the patient returned to underground work. The only symptom now is that the joint tires more quickly than its fellow. Post. Cruciate Injury is exceedingly rare in miners. The violence causing the injury is applied to the head of the tibia, driving it backwards, and this is not a common happening in miners; the position adopted at work is against such a happening. (See figs. 5, 6 & 7).

In no case of cruciate injury has the writer attempted a reconstruction operation. It is a truism worth repetition that, if assiduous development of the quadriceps and hamstrings does not produce a useful joint, then no reconstruction operation is likely to be more effective. (Refs. 11 & 34).

(d) Injuries of the Menisci. (Ref. 35).

These injuries are met with almost daily in colliery districts. If reference is made to Figs. 5, 6 & 7, the reason becomes obvious. It will be noted that the miner (fillers especially) sits on his heels, i.e. he has his knees fully flexed. He holds his shovel in his right or left hand, fills it and throws the coal on to a conveyor. As he does this he twists his body and simultaneously extends the knees slightly. Thus we have well demonstrated the mechanism causing tears of the menisci. If he throws the coal to the left, the right femur, as it extends, is internally rotated on the fixed tibia, and the medial meniscus of the right knee is in danger. It is important to realize that the accident occurs in the flexed knee:

when the knee is in extension no rotation of the femur on the tibia is possible and therefore tears cannot occur. From the nature of their work, miners often have remarkably lax knee ligaments and undoubtedly this predisposes to cartilage injuries. The tibia abducts readily on the femur and the joint space is thus increased, giving added freedom to the medial cartilage to move.

External cartilage tears, conversely, are caused by internal rotation and adduction, a much less frequent twist. In practice it is found that out of ten torn cartilages, eight or nine are medial.

Symptoms, Signs and Diagnosis of Medial Cartilage Injuries.

(1) In a classical case of "bucket handle" tear, with prolapse of the torn portion into the intercondylar space, the symptoms are definite. The knee is flexed to about 15°: there is pain; an effusion develops within a few hours; local tenderness is present over the anterior semilunar point, and passive extension causes acute pain at the same point. A peculiar and very characteristic elastic resistance is felt. Flexion is relatively painless.

Treatment consists in resting the knee over a pillow for a few days until the severe pain subsides. Then an attempt should be made to "reduce" the prolapsed portion. The manipulation consists in fully flexing the knee, abducting and internally rotating the tibia, and then rapidly extending the joint. If successful, full painless extension is obtained and the elastic resistance vanishes. Thereafter

the knee is firmly bandaged with wool and crepe, and rested.
Within 24 hours active quadriceps drill can be commenced
and by the end of 10 days, if the effusion has subsided,
cautious weightbearing is allowed.

If this manipulative treatment fails , the position
should be explained to the patient, and two courses are then
open (1) manipulation under anaesthesia or (2) immediate
operation.   In the author's practice amongst miners,
operation is usually advised.   Conservative treatment fails
in many cases.

(2) <u>Posterior Third Tears</u> are often more difficult of
diagnosis.   There may be no locking, but the patient states
that the knee suddenly gives way.   There is associated
quadriceps atrophy, and complaint of difficulty on going
downstairs is usually made.   Examination of such a case is
frequently negative, and one is left in doubt.   It is here
that McMurray's Test fills such a useful place.   The knee
joint is flexed fully, the leg is abducted, the foot is
externally rotated, and slowly and deliberately the knee is
extended.   In a posterior tear, when the medial condyle
passes over the torn portion, the patient complains of pain
and a "click" is felt, and sometimes heard.   With experience
one is soon able to differentiate a true cartilage "click"
from other "clicks" felt about the joint, e.g. patella,
tendon etc.   In such a case, operation is advised, unless
there is strong contraindication.

(3) Pedicled Tears, Tags etc.

Some of these cases give anomalous signs and symptoms.
The reason is not difficult to find, as the type of injury
allows the damaged part to move freely about the joint and

FIG. 38.

Diagram of
'Tag' tear of
Medial
Cartilege.
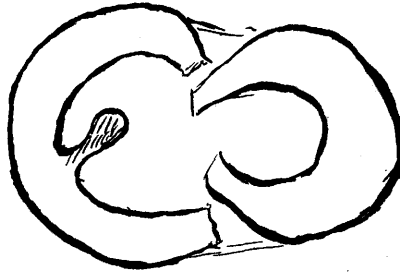
It is obvious that instead of being "nipped", the tag slips
away with great readiness.   This can be demonstrated
beautifully at operation.   The "tag" tear is one of the few
types that can be palpated.   The mechanism is shown in the
accompanying diagram -

FIG. 39.

'Tag' tear of
Medial Cart-
ilege. The
Tag lies
between
capsule and
condyle and
is palpable.
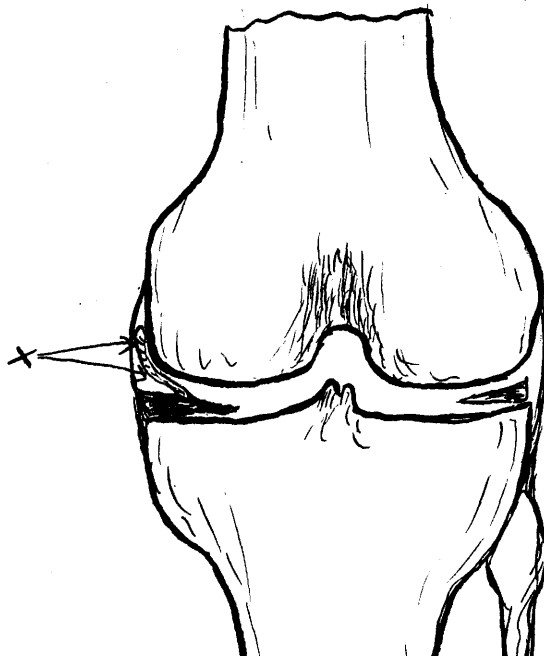
The pedicled torn portion falls across the cartilage and lies between the femoral condyle and the capsule, where it is readily felt against the condyle.

(4) Cartilage Injuries in Elderly Miners.

This is one of the most difficult types of case to deal with.   Osteo-arthritic change is frequent, and operation leads to severe quadriceps atrophy, a condition not readily curable in a miner of 55.   The writer attempts to assess the risks as follows :-

(a) General fitness, cardio-vascular etc.

(b) Type - thin, wiry; or fat, plethoric.

(c) Morale.

(d) The patient's wishes.

If the patient is a fit miner of 50, of the thin active type and with good morale, then operation is advised.   But a plethoric type, with slow movements and general hypotonicity of muscle, stands operation badly, and the knee joint may never recover.

In one case of the author's, where there was a palpable tag tear, the miner, active and healthy although 62 years old, was complaining bitterly of this little " pellet jumping about at the side of his knee".   His age was against operation, but the symptoms were persistent, and operation was ultimately carried out.   This consisted of making an incision about 1" long over the palpable tag, removing the torn portion, and closing the joint; in other words a partial meniscectomy was performed.   The case did well.

Symptoms, Signs and Diagnosis of External Cartilage Injuries.

The history may guide one, but frequently there is some doubt. Locking is an infrequent finding. The chief complaint is of sudden giving way of the knee, associated with pain on the outer side of the joint. An important sign is clicking as the knee is extended. No test is necessary to demonstrate this click: the patient will flex his knee fully and then extend it. Towards the end of the extension there is a loud click, heard and felt, and one can often see a movement of the component bones of the joint. The click is always heard at the same angle of flexion.

It is interesting to watch the miner, who has perhaps had a torn external cartilage for 3 - 6 months, demonstrating the click. He sits down on his "hunkers" and forcibly flexes the knee: in this position he can tell if the "cartilage is out". Perhaps he has to sit with the foot internally rotated, and move back and forward on the flexed knee, before the cartilage "goes out". Then he rises and straightens the knee and the loud report is heard. Many miners with a torn external cartilage go on working for several weeks before deciding to have an operation. The momentary locking and unlocking met with in these cases, does not worry the miner in the way that a true, painful, lock due to a torn medial cartilage does.

In such cases operation is the only treatment of value.

Differential Diagnosis :-

(1) Sprain of Collateral Ligaments,

    Note (a) the history,

         (b) the point of tenderness,

         (c) absence of true locking,

         (d) response to treatment.

(2) Sprain of Tibial Collateral Ligament at cartilage attachment,

    Note (a) point of tenderness,

         (b) response to treatment,

         (c) re-examination after 7 - 10 days rest - ? locking,

            ? cartilage tenderness.

(3) Nipping of Alar Pad of Fat,

    Note (a) site of tenderness is central, with tenderness

            close to, and on either side of patellar ligament,

         (b) no true locking, though full extension causes

            pain centrally,

         (c) rapid response to heel raise and quadriceps drill.

(4) Loose Bodies,

    Note (a) x-ray,

         (b) various sites of pain,

         (c) inconsistency of symptoms.

(5) Osteo-arthritis,

    Note (a) age,

         (b) history of old injury,

         (c) morning stiffness,

         (d) coarse crepitus on movement,

         (e) x-ray.

(6) <u>Cystic degeneration of External Cartilage</u>,

Note (a) type of pain - ache,

(b) swelling - more tense on extension,

(c) complaint is usually of aching, not of locking,
or of giving way.

<u>Operation for the Removal of a Cartilage.</u>

Preliminary quadriceps exercises are very valuable, not
so much from the point of view of developing the muscle, as
from the fact that the patient "learns" how to contract his
muscle actively, and so loses no time after the operation.

The author uses Timbrell Fisher's incision and if
necessary, adds a second incision behind the collateral
ligament if there is difficulty with the posterior horn.
On opening the joint, a general inspection is first made for
presence of osteo-arthritis, loose bodies etc.   The anterior
horn is first detached and held with Martin's cartilage forceps.
The cartilage is then separated from the capsule, and this
is facilitated by using Mercer's knife,   (Ref. 36).
or a curved knife of the Lowe : Breck type.   If there is
difficulty with the posterior third, or if a transverse tear
allows the anterior two-thirds to come away, leaving the
other part, then a second small lateral incision behind the
collateral ligament is made.   The capsule is incised and
the posterior horn is seen.   It is then removed.   The wound
is closed, using fine catgut for the synovial membrane
and extra-synovial fat, and a second fine catgut suture for
the capsule.   Silkworm gut is used for the skin.   A firm,

extensive, padded dressing is applied before the tourniquet is removed.

On the following day, or second post-operative day, active quadriceps contraction is started. The stitches are removed on the tenth day and on the twelfth day he is allowed up.

Removal of an external cartilage is effected in a similar way. The anterior horn is deeper in the joint, but the posterior is of easier access than in the case of the medial. For some reason, not easily explained, recovery after external meniscectomy is not so rapid as after the medial operation.
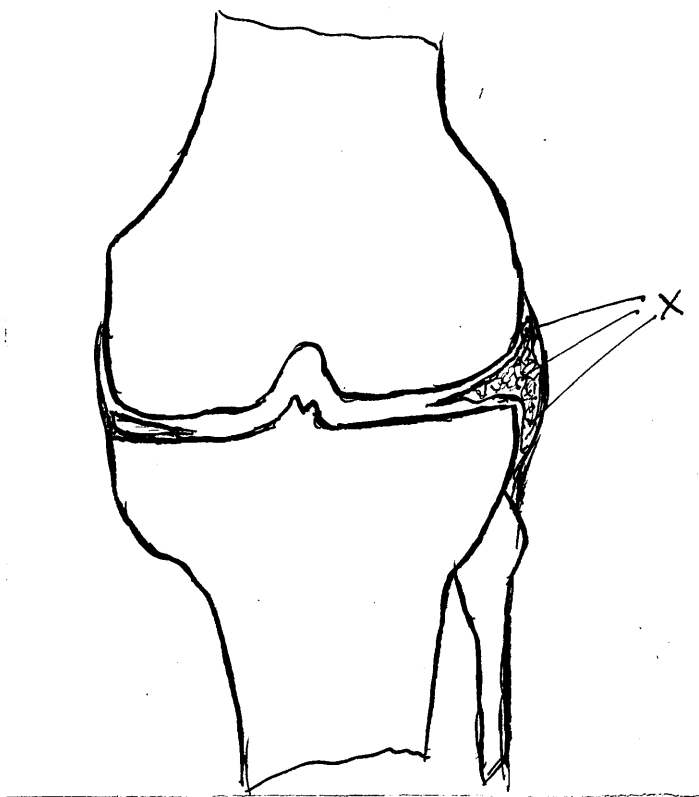
(e) Cystic Degeneration of the External Cartilage. (Ref. 37).

About a dozen of these cases have been met with, four being in miners. In all cases there was a history of injury. But in colliery work it is easy to recollect an injury once a lesion has been found!

The symptoms and signs are usually definite. A complaint of aching pain "like toothache", a swelling in the joint line on the outer side of the knee, made more tense on extension, all point to the diagnosis. The only treatment of any value in a miner is removal. The operation is by no means easy as quite an extensive dissection may be necessary. In one case the cyst had "mushroomed" upwards and downwards (see Fig. 40) and its removal left a huge synovial gap. It is most important to avoid damage to the fibular collateral ligament and the popliteus tendon. Recovery is much slower in these cases. A persistent effusion may be troublesome, and may require aspiration.

FIG. 40.

Cystic Degeneration of External Cartilege.

Return to Work.

Amongst young miners, recovery is usually complete
by the end of the sixth week. Although many of these men
are willing to resume their former occupation at once, it is
the author's practice to advise light work for a period of
2 - 6 weeks.   By so doing, the severe strains and stresses
of coal-face work are avoided, strains that in many cases
would lead to an effusion.   In the case of the older miners,
it is by no means easy to return meniscectomy cases to their
full work, and a proportion become permanent light work
cases.

Results of Operative Treatment :-   (Refs. 38, 39, 40.)

A series of 56 consecutive meniscectomies in miners was studied, and certain interesting and instructive findings were obtained.   Of the 56 cases, 47 showed tears of the medial cartilage; 6 tears of the external, and 3 cysts of the external cartilage.   Therefore, of 54 torn cartilages, 83.9% were medials and 16.1% externals.   This figure agrees with Adamson's experience (Ref. 40).   The average age was 35;   youngest 17, oldest 53.

Analysis of types of Cartilage Injury.

TABLE 14.   Medial Cartilages.

Lesion	No.
Varieties of "Bucket Handle" Tears	32
"Tags" or Pedicled Tears	5
Posterior Third Tears - Transverse or oblique	7
No Tears : abnormal mobility	3
TOTAL	47

TABLE 15.   External Cartilages.

Lesion	No.
Varieties of "Bucket Handle" Tears	4
"Tags" or Pedicled Tears	0
Posterior Third Tears	0
No Tear: Abnormal mobility	2
Cystic Degeneration	3
TOTAL	9

Analysis of Disability Periods in Cases
returning to pre-accident work.

TABLE 16.

Medial				External		
Age Group	No.	Average Disability Period in days		Age Group	No.	Average Disability Period in days
15-25	7	57		15-25	2	79
✗26-35	18	107 (1 Case-309)		26-35	4	94
36-50	18	75		36-50	-	-
51-70	1	147		51-70	-	-
				Cysts	3	68

✗ Note one case - 390 days disability.   Extreme quadriceps

atrophy, plus persistent effusion, resisting all forms of

treatment for many months.

Analysis of Cases not returning to pre-accident work.

TABLE 17.

(a) Medial Cartilages.

	Age	Lesion	Category	Remarks
1	53	Posterior third tear	Permanent partial disability	Osteo-arthritis, progressive since operation.
2	39	"Bucket Handle" tear	Permanent partial disability	Laxity of cruciate ligaments, persistent quadriceps atrophy and subjective weakness.
3	49	"Bucket Handle" tear	Permanent partial disability	Laxity of cruciate ligaments. Poor morale. Complained of pain and weakness of knee.

TABLE 18.

(b) External Cartilages.

Nil.

Therefore, out of a total of 56 cases, 53 (or 94.6%) returned to pre-accident work.

Average Disability Period of those Cases returning

to Pre-accident Work.   (All cases.)

TABLE 19.

No. of Cases returning to Pre-accident Work.	Average Disability Period.
53	84 days

Adamson's recent paper (Ref. 40) has been studied with great interest, and an attempt is made in the following table to compare his figures with the author's.

Medial Cartilages.

Adamson - Total No. 54.

Author   - Total No. 48.

TABLE 20.

	No. returning to full work by					Total	%
	$2\frac{1}{2}$ months	3 months	$3\frac{1}{2}$ months	4 months	$4\frac{1}{2}$ months		
Adamson	3	11	9	6	10	39	72
Author	23	5	6	3	1	38	79

Allowing for the relatively small numbers, it appears that the unorthodox treatment recommended by Adamson in the post-operative stage is not justified by results.

(d) <u>Fractures and Dislocations of the Lower Limb</u>.

(1) <u>Hip Region</u> :-

  (a) <u>Dislocations</u>.

  Dislocation of the hip is not a common injury in miners, the incidence in the author's experience being about 2 cases per year in a mining population of 9,000.

  The accident occurs when a fall of roof impinges on the back and pelvis of the miner when he is in a stooping position, i.e. when his legs are flexed on the pelvis.(See Fig. 41)
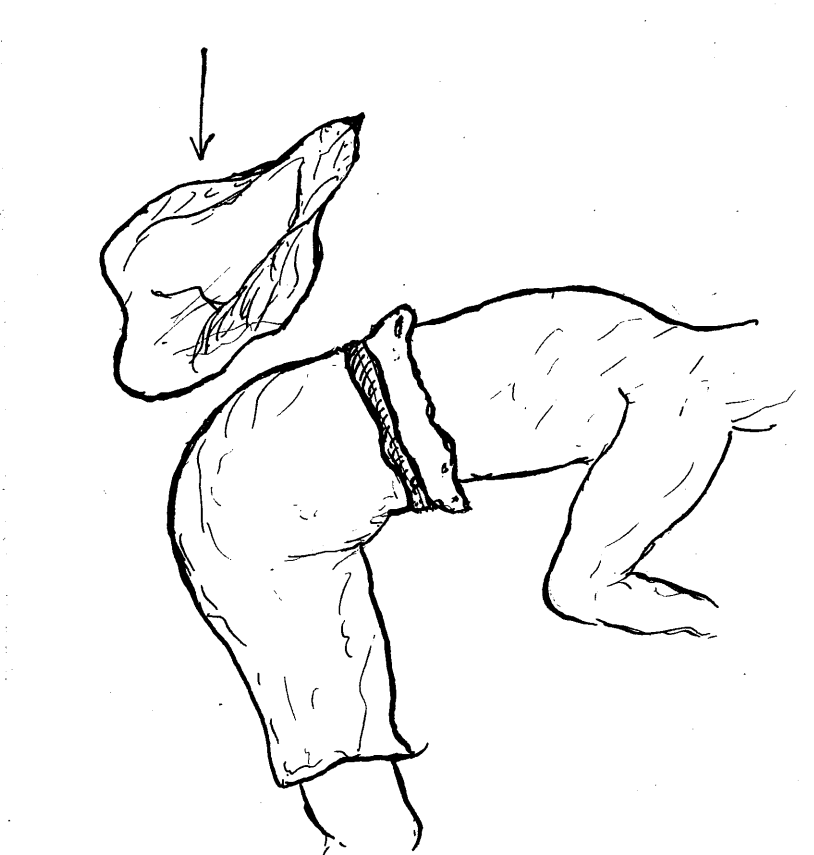
<u>Fig. 41</u>.

Figure illustrating the violence causing posterior dislocation of the hip in miners.

The pelvis is driven forwards, and the head of the femur comes to lie behind the acetabulum. No case of anterior dislocation has been seen in miners.

The clinical signs are striking. The patient, usually in extreme pain, lies with the leg flexed, adducted and internally rotated. (See Fig. 42).

FIG. 42.

Any attempt to move the leg brings forth an agonizing cry. Once seen the condition is never forgotten. Before undertaking an x-ray examination, the patient should be given Morphia. (See Fig. 43).

FIG. 43.

Posterior
Dislocation
of Hip Joint.

Careful x-ray examination is necessary to exclude
associated fracture of the acetabulum.   Usually if there
is a fracture, the detached portion is small and is accurately
replaced when the head is reduced; but, if the chip is
judged to comprise one-third or more of the acetabulum, then,
after reduction, extension should be maintained for six
weeks at least, and careful check x-ray examination made to
ensure that the head does not re-dislocate.

Avascular necrosis of the femoral head is a very serious
complication.   If the vessels to the head entering via the
capsule and the ligamentum teres, are damaged, or torn
across, then the nutrition of the head is lost.   X-rays
taken about the 8th - 10th week demonstrates the relative x-ray
density of the head.   Probably, osteo-arthritis, occurring

months or years after the accident, is due to an incomplete
cutting off of the blood supply.   (Ref. 41).

Myositis Ossificans is another serious complication,
as a remarkable amount of new bone may be laid down,
interfering considerably with movement.   There is no doubt,
in the writer's experience, that it is largely preventable,
by (1) early reduction and (2) avoidance of early movements
of the joint.

Treatment.   Reduction of a posterior dislocation is
accomplished by Bigelow's Manoeuvre.   This method has
failed in only one case - where there was a chip fracture
of the head preventing it from "snapping" into the
acetabulum.   Watson Jones' method failed equally in this
case.   (Ref. 11).

Bigelow's method is best carried out on the floor.
The patient is placed on a mattress and anaesthetised, not
with gas and O_2, but with full ether.   Chloroform, whilst
giving excellent muscle relaxation, is dangerous in a
shocked patient.   The pelvis is steadied by an assistant.
The affected leg is grasped by the Surgeon, and, with the
knee held at right angles, the hip is flexed, externally
rotated, and then slowly and deliberately extended into the
neutral position.   Reduction is effected with a satisfactory
deep-seated snap.   A check x-ray is then taken.   If there
is a chip fracture of the acetabulum, the leg is immobilized
in a hip spica plaster for 6 - 8 weeks.   In a dislocation
with no complicating factors, no splint is necessary, but

the patient is kept in bed for 6 weeks.   If there is a
large chip fracture, extension is maintained for 6 weeks
and check x-rays taken weekly.

In a simple, uncomplicated case, after 4 weeks an x-ray
is taken.   If there is no evidence of myositis, active
non-weight bearing movements are commenced.   These exercises
are continued for 14 days, and then weight bearing is
allowed.

Central Dislocation of the Hip.

See fractures of Pelvis - p. 152.

(b) Fracture of the femoral neck is not met with as a
mine accident.

(c) Pertrochanteric Fractures are seen occasionally,
and, as the patients are usually fit, operative treatment
is undertaken.   Nailing the fracture with a Watson Jones
Type Triple Flange nail gives excellent results in suitable
cases, but there are certain cases not adapted to this
treatment.   If the fracture is comminuted, and if it appears
that there is insufficient firm bone to hold the neck of
the nail, then operation using a Watson Jones nail is
contra-indicated.   (See Fig. 44).

FIG. 44.

←suitable

unsuitable →
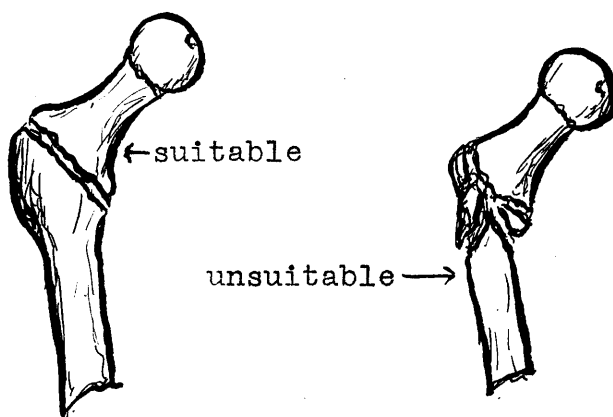
Watson Jones (Ref. 11) states that there should be at least 1" thickness of bone to hold the nail (See Fig. 44), and this, in the writer's experience, is sound advice. The nail should be inserted at a point about $1\frac{1}{2}$" below the great trochanter, and is driven in much more vertically than in the case of fractures of the neck. The results in suitable cases are excellent: union is rapid, and a quick recovery of movement follows. Even in elderly miners, the operation is well tolerated and recovery gratifying. Local anaesthesia is quite satisfactory in these cases, and, if need be, gas and oxygen, or gas, oxygen and trilene can be given when the nail is being hammered.

Where there is comminution of the bone, and especially where there is insufficient bone to hold the neck of the nail, treatment with a Watson Jones Type Three flange nail is not suitable. But the recent introduction of the Blount and Neufeld Types of nails (Refs. 42, 43 & 44) obviously surmounts many of the difficulties. Here a V-shaped nail is joined on to a plate which lies along the shaft of the femur. The nail is inserted, and the plate is fixed by screws to the shaft.

If such an operation is not considered advisable, Well-Leg Traction using the Roger Anderson Splint is the treatment of choice, and good results are obtained (Ref. 45). The only criticism is that there is a danger of the knee of the affected leg becoming stiff.

In miners, therefore the treatment may be summarised as follows:-

Pertrochanter Fractures.

Patient	Fracture	Treatment
Young and healthy	Non-comminuted	Triple Flange Nail
	Comminuted	Blount or Neufeld Nail
Elderly: Healthy.	Non-comminuted	Triple Flange Nail
	Comminuted	Well-Leg Traction
Elderly: considerable operation risk.	Any Type	Well-Leg Traction

FIG. 45.

Pertrochanter Fracture -

Suitable for nailing.

FIG. 46.

Pertrochanter
Fracture -

Unsuitable for
nailing.

FIG. 47.

Pertrochanter
Fracture -

Showing guide
in position.

FIG. 48.

Pertrochanter
Fracture –

Showing nail in
position.

FIG. 49.

Pertrochanter
Fracture –

Showing late
result of
nailing.

(2) Fractures of the Shaft of the Femur.

(a) Upper Third Fractures are rare.   Treatment with
Well-Leg traction is the most reliable method.   The
patient sits up in bed, and by this means the flexed upper
fragment is aligned with the shaft.

(b) Mid-shaft Fractures are more common.   These cases
are treated in a Thomas' Splint, angled at the knee.   The
splint is used, not in the Liverpool manner, but as a sling.
Continuous sketal traction, with a Kirschner wire through
the tibial tuberosity, is maintained by weights.

Under anaesthesia, an attempt is made to reduce the
fracture, and a small posterior splint, of Gooch type, is
applied to the thigh.   After 5 - 6 weeks the sketal traction
is replaced by skin traction.

In the course of treatment, check x-rays, using a
mobile machine, must be taken regularly.   It is most
important to avoid sagging of the femur at the site of the
fracture, and the only way to prevent this is by daily
supervision.

The standard of reduction is as follows :- A.P. axis -
perfect, Lateral axis - perfect: Apposition - one third
apposition is satisfactory, but naturally complete apposition
is the ideal.   It is not easily got.   After 12 weeks
union is usually firm, but all cases must be judged separately
on clinical and radiological evidence.

During the long period of immobilization, every effort
must be made to prevent atrophy of muscles.   It is of little
value lecturing a patient: a masseuse must be detailed to

instruct and supervise the exercises.   The following

scheme is used by the writer :-

(1) Preliminary deep breathing exercises and shoulder exercises,

(2) Foot and Toes - Dorsiflexion, plantar flexion: inversion

and eversion of the foot.   Dorsiflexion: plantar flexion

and spreading of the toes,

(3) Active contraction of quadriceps - at first without

resistence: later with resistence of the masseuse's hand

holding the patella.   (See Fig. 50).

<p align="center">FIG. 50.</p>
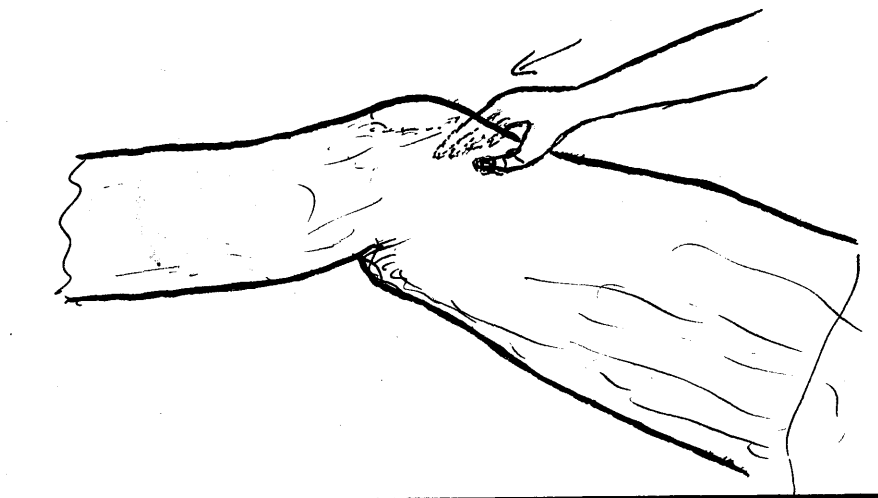
This stimulates the patient, and is of considerable value

in maintaining good muscle tone.

If union is considered satisfactory, a walking caliper

splint is fitted, and the patient at once commences active

non weightbearing exercises.   It is at this point that the

value of a good masseuse is most evident;   the patient is

often nervous, and needs encouragement: sympathetic, yet firm, handling by the masseuse can overcome the patient's fears, and stimulate activity and enthusiasm.   The patient should take an interest in the progress of his case.   He should see the measurement of the flexion of the knee and of the circumference of his thigh, and should be made a partner in the difficult and slow business of rehabilitating his leg.   After a varying period - $4\frac{1}{2}$ to 5 months, weight bearing is commenced.   At first the caliper is removed for a few minutes, and a few steps taken under the supervision of the masseuse.   This period is gradually increased from a few minutes to half an hour, and so on. Sticks, with a rubber end piece, are helpful at this stage, but the patient must be encouraged, as soon as possible, to dispense with all aid.   Progress in the young man is usually steady, and a range of flexion of the knee just short of normal is obtained.   In the older miner (45 - 65), results are frequently disappointing.   Flexion to a right angle, or a few degrees beyond, is only too often the best that can be attained.

Obviously this question of knee flexion is of prime importance to the miner, and reference to p. 13 explains this.   There is no disability so serious from the miner's point of view as a stiff knee.   He is quite unable to tackle "face" jobs where he has to crouch or sit in low, awkward places.

(c) Supracondylar Fractures are rarely met with.
This fracture is treated in a Bohler-Braun Frame so
arranged that the angle is directly under the site of
fracture.

Extension is maintained by means of a Kirschner wire
or Steinmann's pin through the tibial tuberosity, with a
weight of 15 - 20 lbs.   The splint is carefully adjusted
so that the angle is at the level of the fracture.   Union
is usually rapid, and in 3 - 4 weeks callus formation is
evident.   The pull may then be reduced by 5 lbs and after
a further period of 3 - 4 weeks, sketal traction is
abandoned in favour of skin traction.

By 10 - 12 weeks time the fracture is usually firmly
united, and the splint can be dispensed with.   The after
treatment is identical to that for a fracture of the shaft.

The writer has not had the opportunity to try the
method advocated by Watson Jones (Ref. 11).   Watson Jones'
condemnation of the above method is forthright, yet the
last case treated by the writer did exceptionally well.
In this case not only was a Bohler's frame used, but a firm
pad (a small sand bag) was placed under the small fragment
at the fracture site.   By dint of careful supervision, a
satisfactory anatomical result was obtained.

(d) Displacement of Lower Femoral Epiphysis has not
been met with.

(3) Fracture of the Patella is almost unknown as a colliery

accident.

(4) Fractures of the Tibia and Fibula.

    (a) Fractures of the External Tuberosity, despite the

frequency of medial ligament sprains, are not common.   It

is important to differentiate the crush fracture from the

shearing type.   In the former, the upper articular surface

of the condyle is comminuted, and, arthritis, no matter

how carefully the fracture is reduced, is almost inevitable.

Where the condyle is sheared off, the fracture line may miss

the articular surface, and, hence , reduction well performed

may give an excellent result.   (See Fig. 51).

<p align="center">FIG. 51.</p>

The severe associated ligamentous injury - the medial ligament and possibly the anterior cruciate - is of great importance and must be remembered in assessing the period of immobilization - 10 - 12 weeks at least being necessary. Of the first importance during the period of immobilization is strict attention to the quadriceps, and even if arthritis develops, a remarkably good functional result may be obtained.

(b) Fracture of the Shaft of the Fibula is seen frequently, the usual cause being a fall of stone or coal. There is often severe associated muscle bruising , and the swelling is considerable. Good quality x-ray plates are necessary for diagnosis. On several occasions a fracture, missed originally, has been seen in a plate taken a few weeks later.

Treatment is simple. Where the patient is of good morale, the leg is strapped with elastoplast: but in the nervous, a short-leg walking plaster is much more efficient. The plaster is retained for 3 - 5 weeks. Recovery of function after removal of the plaster is rapid.

(c) Fractures of the Shaft of the Tibia and Fibula.

Greenstick fractures are met with in boys - often as a result of tub accidents. There is no over-riding, but the tibia may be angulated. This is easily corrected under anaesthesia, and thereafter, a plaster cast is applied from the groin to the toes. A check x-ray is then taken. If there is any persistent angulation, this is easily corrected by wedging of the plaster. Wedging is such a

valuable manoeuvre that it is surprising to the writer
that so many house-surgeons have never seen or heard of the
technique. The following method has been used with great
success for many years :-

(1) A.P. and lateral x-rays are taken,

(2) If the angulation is in one plane only, the problem is
    simple,

(3) The x-ray showing the angulation is placed against a
    glass window, and the axis of the two fragments is
    drawn on the plate - AB and BC (See Fig. 52).

<div align="center">FIG. 52.</div>
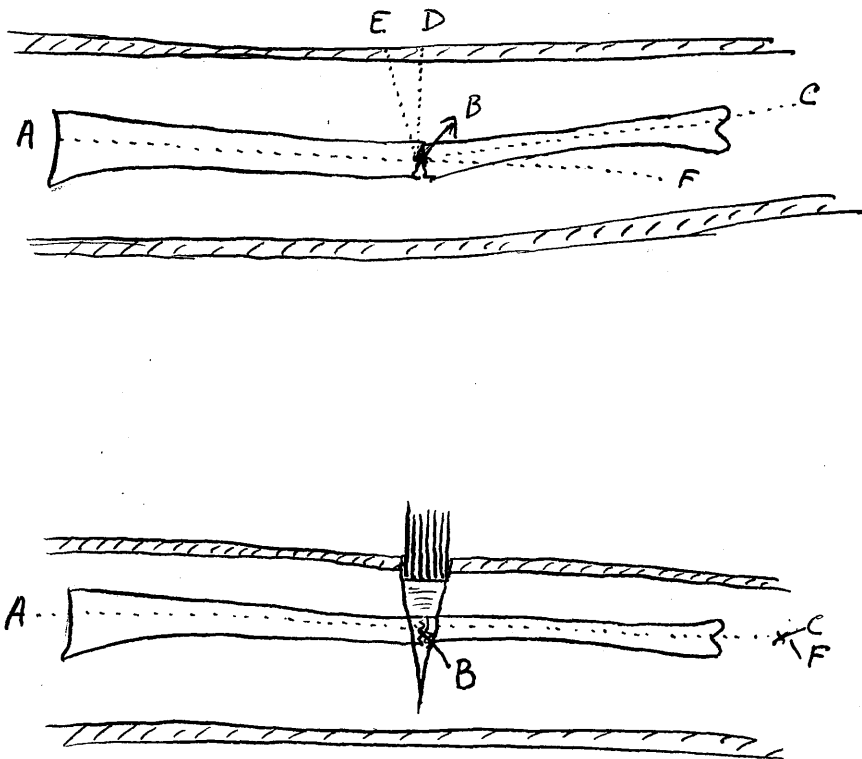
(4) From point B, BD is drawn at 90° to AB, and BE at

90° to BC.   The angle DBE equals the angle of

angulation CBF.   The distance ED is measured on the

x-ray shadow of the plaster,

(5) The plaster is cut exactly at the site of fracture from

side to side, and over the side of the open angle ABC.

The plaster is then gently and firmly forced, and the

saw cut opens: this opening is maintained either by

wooden wedges, or (as the writer uses) pieces of

wooden tongue spatulae,

(6) The plaster is then repaired, and the spatulae withdrawn

when the repair is hard.   The hole left by the wedge

is filled loosely with wool, and then covered with a

few turns of plaster.   This prevents window oedema,

(7) A check x-ray is taken.

Where there is double angulation i.e. in two planes,

provided it is not too great, wedging can still be used.

In such a case the plaster is cut as for an anterior

angulation, and then cut as for a lateral angulation, thus

leaving only one quarter of the circumference of the plaster

intact.   The anterior angle is corrected by wedges, and

then the lateral, and, before repairing the plaster, a

check x-ray is taken.   If the position is satisfactory,

the plaster is then completed.

The theoretical dangers of wedging are never encountered,

provided the method is not used to correct gross angulation -

a position that should not arise in the hands of a competent

fracture surgeon.

(d) Fracture of the Tibia and Fibula with over-riding.

A common pit injury, and one that is frequently compound. Its importance cannot be over emphasized. The Diagnosis is usually simple; all the classical signs of fracture are present and obvious. There may be doubt as to a fracture being compound, where there is a small, puncture wound, near the fracture site. It is a sound general rule to treat such a case as compound. No harm is done by exploring the wound, but great harm can be done by leaving it. Before undertaking treatment A.P. and Lateral x-ray plates are taken.

Treatment.

(1) Compound Fractures.

After the shock has been treated, the patient is taken to the theatre. The surgeon himself attends to the skin preparation. There is no final agreement as to what constitutes the ideal method. The author places a gauze wrung out of 1 in 1000 Acriflavine over the wound, and then washes the remainder of the leg with spirit soap and water. The leg is then shaved if necessary. The soap is removed: the limb dried, and iodine applied. Gloves and gown are changed, and the operation proceeds. The wound edges are excised, the aim being to remove about 2 m.m. of skin all round, but varying this if necessary, e.g. if one part is severely contused more may be removed at that point. The fracture is usually seen clearly now. The muscles adjacent to the fracture are examined, and, as no tourniquet is used, any change in the colour is noted

at once.   Any dead, or devitalised muscle is excised

with scissors until healthy bleeding muscle is reached.

any foreign bodies are removed and any small detached bony

fragments.   If the periosteum shows ingrained dirt, this

is removed with a scalpel or sharp chisel.   If tendons are

cut, no attempt is made to suture these, and the same

principle applies to nerves and muscles.   Buried catgut

must be avoided, the only exception being where a large

artery requires ligature.   No plates or screws are permitted.

All recesses are carefully examined, and if necessary, the

wound is enlarged in the axis of the limb to permit careful

inspection.   Where there is severe muscle damage, the

deep fascia should be incised upwards and downwards over

the affected area.   The wound is then "frosted" with 5 gms.

sulphanilamide, by means of the R.A.F. insufflator - a most

useful instrument.   The decision as to closure is, at times,

very difficult, but if consideration is given to (1) the

time since the accident, (2) the tension of the skin and

(3) the amount of tissue damage, then the problem is

simplified.   Any compound fracture of over 8 hours, should

be treated by the open method; and tension of the skin is

an absolute contra-indication to closure.   But if the

fracture is seen early, and if the wound is small and closes

readily, then the benefits of primary closure should not

be neglected.

Gissane (Ref. 46) adopted the idea of applying Thiersch

grafts where there is any difficulty in closure, but the

writer has no experience of this method.

If the wound is left open - a vaseline gauze is lightly packed into the wound and a wool dressing applied. The fracture is then treated as if it were a closed one. This may necessitate (a) manual traction and manipulation or (b) skeletal traction by Kirschner wire or Steinmann pin through the lower end of the tibia, followed by manipulation and application of plaster. The plaster is immediately cut.

Ante-gas gangrene serum and A.T.S. are administered in theatre. Prophylactic Sulphanilamide is continued, and an hourly pulse chart is kept for three days. The good rule of the 1914-18 war surgeons that "a sudden unexplained rise in the pulse in a case of compound fracture means gas gangrene" is worth repetition. If all goes well, the case is treated as a closed fracture.

(2) Simple Fractures.

In over-riding fractures one is up against a type of fracture difficult to reduce, and difficult to keep reduced. (See Fig. 53).

FIG. 53.
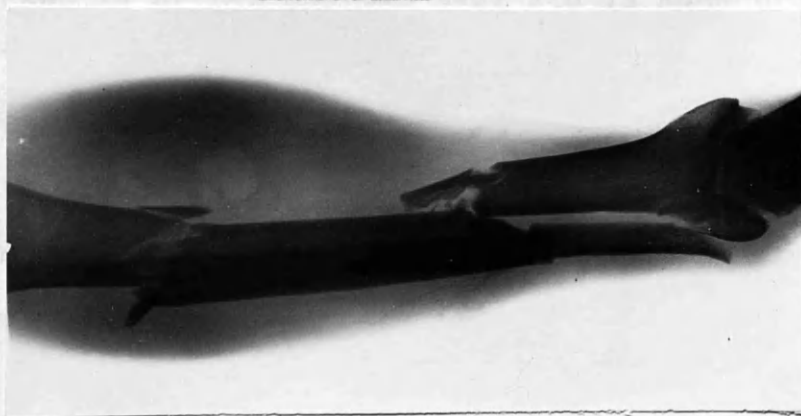
If the fracture line is transverse, a successful manipulation will suffice.   But that is the exceptional type.   In most cases the fracture line is more or less oblique, and simple reduction and plaster is useless.
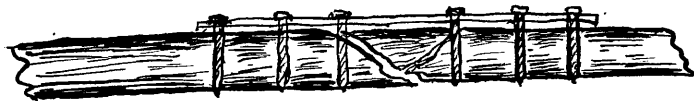
In young healthy miners the writer favours operation. Two methods are used.   In the 45° oblique fracture, the single screw method of fixation is quick, simple and efficient.   (See Fig. 54).

FIG. 54.

(1).

(2).

The screw used is of the Sherman type and is made of non-toxic steel (Down Bros.).   (Ref. 47).

When the fracture does not allow of this, a plating operation is necessary.   Non-toxic steel plates (Burns Type) and non-toxic steel screws (Sherman Type) are used. With the use of modern plates and screws, no rarefaction of bone is met with around the plate and screws, and union

is rapid and sound.   (Fig. 54 - (2)).

If the above methods are not applicable (e.g. the presence of scabies, or varicose eczema etc.) skeletal traction is used.   It is probably safer to insert the wire or pin through the lower end of the tibia, though the skin condition may force one to use the oscalcis.   The fracture is then pulled out on a Böhler traction apparatus and the fracture manipulated.   A plaster is applied from the toes to the tibial condyles;   the leg is then taken out of the frame, and, with traction maintained, the plaster is continued up to the groin with the knee joint flexed $25^\circ - 30^\circ$.   In bed, the leg is placed on a Bohler-Braun frame and continuous traction maintained with a weight of 10 - 15 lbs.:   in some muscular miners even 15 - 20 lbs. is required.   A very careful check on Distraction must be kept.   In the writer's experience it is the most potent factor of all in delaying union.   After 5 - 10 days the plaster becomes slack, and must be changed. The same procedure must be gone through, as the fragments are still very mobile.   Another check x-ray is taken, and if satisfactory, treatment continues.   If any angulation is found, this is corrected by wedging.

X-ray examination, with the plaster in place enables one to form an idea of the progress of union.   Usually in 7 - 8 weeks, well mineralized callus is obvious, and the plaster may then be removed for clinical testing of union.   If there is tenderness at the fracture site, a

long leg walking plaster is applied, again with the knee flexed. A further review of the case in a month's time is made, and the plaster is finally discarded when x-ray and clinical examination indicate firm union. An Unna's paste bandage is then applied, from the base of the toes to the lower thigh. Supervised exercises and games are continued. The Unna's paste bandage is only discarded when no appreciable swelling occurs after a day's activity.

Fractures of the Lower third of the Tibia, in elderly miners, are treated with great respect by the writer. It has been noted in such cases that union is slow, oedema of the foot and ankle is severe and restoration of function difficult. The fracture is usually oblique and unstable and requires skeletal traction. After the fracture is consolidated and weight-bearing is commenced, complaint of aching at the site of fracture , and of pain around the ankle joint is only too frequent.

Non-union of tibial fractures is a rare complication in miners. In the cases dealt with by the author, reliance has always been placed on inlay bone grafts. The fracture is exposed and the sclerotic bone ends are drilled thoroughly in all directions, and any dense scar tissue is excised. A gutter is then removed by means of an Albee saw and a graft cut from the other tibia. The graft is cut so as to fit tightly and screw fixation is not usually necessary. The leg is then immobilized in a long leg plaster. So far, all the author's cases treated by inlay grafting have progressed to union. Recently,

cancellous chips removed from the ilium have been used in
a case of non-union of ulna and very rapid union was
obtained.   This rapidity of union with the use of
cancellous grafts is confirmed by recent reports.   (Refs.
48 and 49).   (See Fig. 55).

FIG. 55.
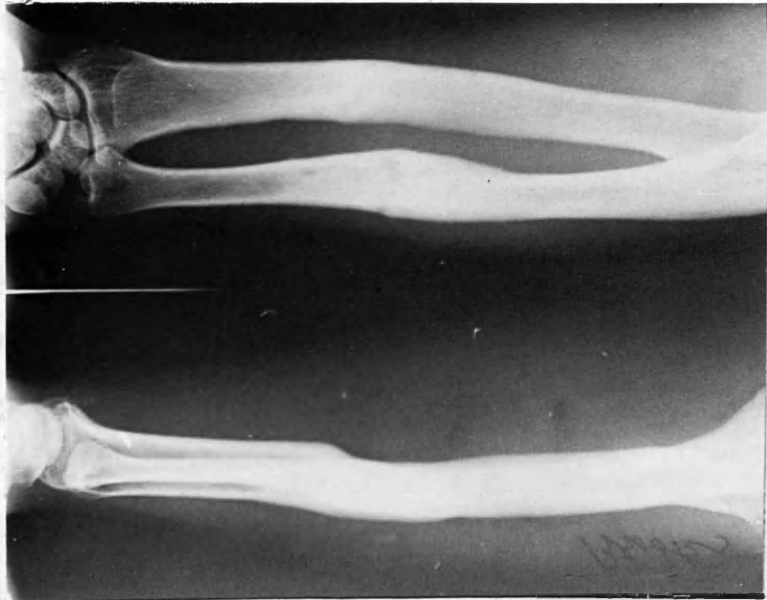
Non-Union of Ulna - treated with Cancellous Bone Chips.

(5) Injuries of the Ankle Region.

(a) Sprains, as is to be expected in view of the
"travelling" underground, are common.   The extraordinary
thing is that they are not more common, when one considers
the wet, slippery, irregular roadways, intersected with
rails, sleepers etc., over which the miner has to walk.
Treatment is usually undertaken by the family doctor and
consists of (1) rest for 1 - 4 days, (2) firm elastoplast
strapping and (3) gradual restoration of weight-bearing.

This method is successful in most cases.   Where there is

a local tender point, the author recommends injection of

2% Novocain as a measure that hastens recovery considerably.

(Ref. 50).

Adhesion formation after sprains is the most common

complication.   Clinically there is full range of movement

in all directions but one - usually inversion - and if this

movement is performed passively, pain is caused.   Palpation

reveals a point of tenderness.   In such a case, manipulation

under full anaesthesia gives dramatic results.

(b) Fractures and Fracture Dislocations of the Ankle.

As one would anticipate these fractures are met with

frequently.   Many are not true abduction or adduction

injuries;   there is often an added rotatory factor.

Ashurst's classification (Ref. 51) is used by the author.

In all ankle injuries, it is very necessary to obtain good

A.P. and lateral x-rays.

Simple 1st Degree Fractures.

(1) External Rotation)
(2) Abduction   )   Fractures.
(3) Adduction   )

The External Rotation fracture is by far the commonest

type.   In all these injuries, x-ray shows a fracture of

one malleolus, but the clinical examination of the

ligament on the other side is of prime importance.   If

there is no tenderness over the ligament, the treatment is

that of a simple first degree injury.

Treatment. A walking plaster, applied for 2 - 3 weeks, is replaced by an Unna's paste supporting bandage. Recovery is usually complete by 6 - 8 weeks.

2nd Degree Injuries - External Rotation,

Abduction,

Adduction,

These important injuries require very careful treatment. Perfect reduction must be the aim of the surgeon, and if this is obtained, the results are excellent.

In the elderly miner the restoration of function is slow, and often aching pain persists for months after the injury.

Treatment. Where there is displacement of the Talus, manipulation under general anaesthesia is necessary. A non-padded plaster is applied from the base of the toes to just below the knee. The plaster bandages must be "wet and sloppy", so that careful moulding around the malleoli may be effected. The foot is placed at right angles to the leg and should not be inverted or everted. After the plaster has hardened, x-rays are taken and these are scrutinized critically. If there is any subluxation of the talus, a further manipulation must be done.

If this is satisfactory, a sorbo rubber heel is fitted, and the patient is allowed to walk. The plaster is retained for a minimum period of 10 weeks, but in elderly men, and in heavily built patients, immobilization is maintained for 12 - 14 weeks. With the plaster in place, exercises are carried out to prevent quadriceps atrophy.

After removal of the plaster, a strong Unna's paste
bandage is applied and intensive exercises are begun.   On
no account must the surgeon be tempted to remove the
supporting bandage until the indications are definite (See
p. 83), as oedema of the foot and ankle is looked on by
most patients as necessitating rest.

In the very obese and plethoric, it may be necessary
to continue wearing a supporting bandage for a year or
longer.   An elastic stocking is the best support and the
patient should put it on before leaving his bed.

3rd Degree Injuries.

The additional marginal fracture of the tibia adds
difficulty in x-ray interpretation, and it may be necessary
to take an oblique view.   Accurate reduction is of even
greater importance in this fracture, as there is now the
added problem of posterior dislocation of the talus.
Therefore the foot must be pulled forwards at the same time
as the plaster is being moulded to the tibia-fibular mortise.
Check x-rays must satisfy the surgeon that (1) the talus
is normally disposed towards the tibial articular surface
and (2) the malleoli are accurately replaced and that there
is no subluxation of the talus medially or laterally.   The
marginal tibial fracture, although it is seldom accurately
replaced, causes no trouble, unless it carries more than
half of the tibial articular surface with it - a very rare
happening.

The accompanying x-rays show a third degree fracture.
Fig. 58 shows on the lateral view, that the talus is still

posteriorly dislocated.   (See Figs. 56, 57 and 58).

FIG. 56.
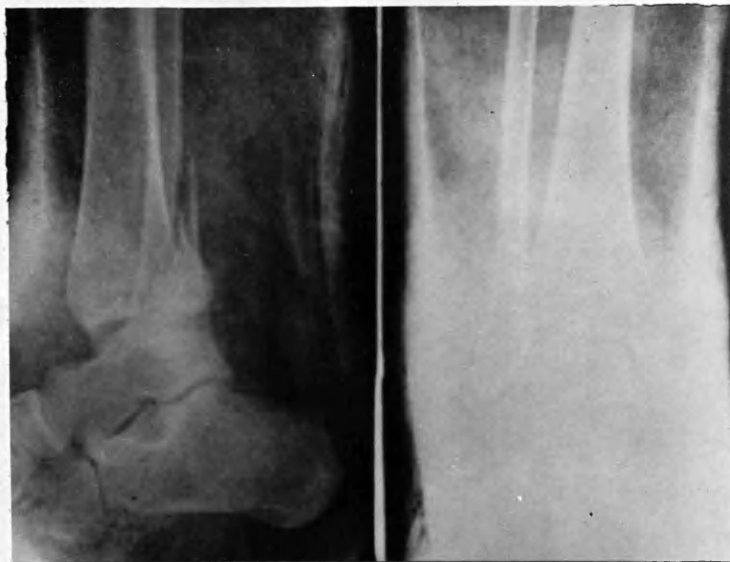

Third

Degree

FIG. 57.   Potts'

Fracture.

FIG. 58.

Lateral view shows that the Talus is still dislocated
backwards.

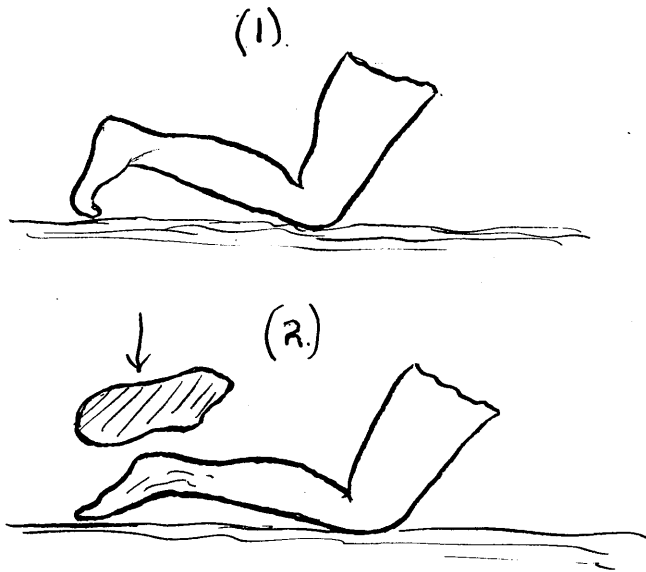Vertical Compression Injuries are not seen in colliery
accidents.

(6) Fractures and Dislocations of the Foot.

(a) Fractures of the Os Calcis are extremely rare in
miners.

(b) Plantar Flexion Sprains.

This is an excellent example of an injury rare in civil
life, yet common among miners.   Fig. 59 demonstrates how
this accident happens.

FIG. 59.

Mechanism of plantar flexion sprain of the ankle
in miners.

(1) Shows the position of the miner's leg and foot when
kneeling.   (2) Shows the stone falling on the heel and
forcing the foot into a position of plantar flexion.   The
anterior part of the capsule of the ankle joint is forcibly
stretched, and a sprain results.   Considerable effusion
follows.   X-ray examination often shows a small flake of
bone pulled up from the neck of the talus.   If early
movements are allowed, new bone is liable to form in the
effused blood at this point.

The correct treatment is immobilization of the foot
at right angles to the leg for 2 - 3 weeks in a walking
plaster.

(c) Fractures and Dislocations of the Astragalus.

No case of the fracture of the neck of the astragalus has been seen in miners.

One case of sub-astragaloid dislocation with fracture of the neck has been met with, but it was impossible to analyse the causative violence accurately. The dislocation in this case reduced easily and accurately by manipulating the foot into full plantar flexion and full eversion. This position was maintained by a padded plaster. At the end of a week, this was replaced by an unpadded plaster, with a walking iron. The plaster was retained for 10 weeks. Thereafter, the heel of the shoe was raised $\frac{1}{2}$", and this was reduced to normal height in four instalments. The result was satisfactory.

(d) Mid-Tarsal Dislocations.

This rare injury has been seen once - in a patient at present under treatment. The dislocation was compound. There was a very extensive flap-laceration of the dorsum of the foot, and the forefoot was dislocated outwards. The wound was carefully excised and the flap replaced - a few loose sutures holding it in place - and the dislocation reduced without difficulty. The limb, immobilized in a cut padded plaster was suspended in a Bohler-Braun frame. Anti Gas Gangrene Serum , A. T. S., and a course of Sulphanilamide, were given. The plaster was removed on the 10th day, and as was feared, the flap,attached distally at the base of the toes, had sloughed. The slough was

removed with scissors, and the wound dressed with sulphanilamide - tulle.   A light plaster was reapplied, but this was changed after a few days for a strong posterior slab splint, so as to prepare the raw area for grafting. The graft - a thick Thiersch - was successful.   A troublesome complication was persistent oedema of the foot, but this ― yielded to repeated elevation and application of Unna'a Paste bandages, and active exercises.   The position at the time of writing, $4\frac{1}{2}$ months from the date of injury, is as follows :- The wound is sound: there is slight oedema of the dorsum of the foot: ankle movements are free, but mid-tarsal movements are considerably restricted.   Extension and flexion of the toes are limited.

(e) Fractures of the Metatarsals.

If reference is made to Table 9, p. 20, it is seen that the foot comes next to the hand in liability to injury in pits.   This has led to the introduction of so-called "safety boots" - a boot made of stout leather and provided with a metal toe-cap.   This undoubtedly has led to a diminution in the number of toe injuries, but the metatarsals are still inadequately protected.   Hence these fractures are still common, and in the older miner must be looked on as serious injuries.   Usually severe bruising accompanies the fracture, and compounding is often seen.   Most of the shaft fractures are not displaced - especially the isolated fractures - and treatment with a well-moulded plaster and a walking iron is simple and effective.   But, when 4 or 5 metatarsals are fractured -

a fairly frequent accident, displacement is often severe
and difficult to correct.   The accompanying x-ray indicates
the type of injury :-

FIG. 60.

Fractures of Metatarsals 2 -5.

In such cases an attempt at simple manipulation and moulding
should always be made.   If reduction is unsatisfactory,
then traction is necessary.   This is best effected by
applying a "banjo" splint of Cramer wire incorporated in
a leg plaster.   The toes of the affected metatarsals are
transfixed with a steel wire and this in turn is fixed
by a piece of rubber tubing or elastic to the outrigger.
The author has always experienced great difficulty in
obtaining accurate reduction, even with the use of such
traction .   The extension must be maintained for 3 - 4
weeks.   Thereafter a well-moulded leg plaster, with a
walking iron, is fitted for a further period of 4 weeks.

As stated above, in elderly miners such an injury is

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very serious.   Despite a good anatomical result, the foot
often remains painful, and rather rigid, and vigorous
rehabilitation does not help much.   It is not easy to
persuade such a man to return to his former occupation e.g.
filling.

/   Fractures of the Metatarsals at the Neck are important
because of the tendency to displacement of the small
fragment down into the sole.   Such a lesion, if not
corrected, causes severe pain on walking.
Treatment is carried out as for oblique shaft fractures
with displacement.   Strong manual pressure on the volar
surface of the head is made by the surgeon, while an
assistant exerts steady traction with a steel wire
transfixing the toe.   The wire is then attached to an
outrigger and treatment is similar thereafter to that of
shaft fractures.

(f) Fractures of the Toes.

(1) Terminal Phalanx.   This, as in the case of the
finger, is an extremely common injury.   The nail is usually
raised by an effusion of blood and there is extreme tenderness.
X-ray often reveals a severely comminuted fracture.   The
big toe suffers most often.
Treatment is conservative.   If the interphalangeal joint
is not involved in the fracture, the toe is encased in a firm,
but not tight, covering of elastoplast.   Elevation of the
foot for a few days is the simplest and most effective way
of alleviating pain.   An ordinary boot with the toe-cap
removed is a favourite device in the ambulant stage, but

if the pain is severe, a leg plaster with an extension under the great toe is more effective.   A walking iron is attached.   The splint can be discarded in 2 weeks and recovery of function is then rapid.   (See Fig. 61).

FIG. 61.

If the interphalangeal joint is involved, manipulation may be necessary to restore the alignment of the articular surface and even continuous traction may be called for if the base is split into two fragments - the "T" type of fracture.

(2) Proximal Phalanx.

The displacement is comparable with that in the fingers and must be treated similarly if there is angulation. Cramer wire 1" wide incorporated in a leg plaster and bent so as to control the angulation is satisfactory. The toe is fixed to the wire with elastoplast and it is seldom necessary to apply traction. The splint is retained for 2 - 3 weeks. X-ray control is necessary, as distraction may lead to delay, or non-union. Non-union has been seen in two cases.

(g) Amputation of Toes.

(1)A severely damaged little toe should be removed at the M.P. joint without hesitation.

(2) In the case of the 2nd, 3rd and 4th toes conservative treatment should be adopted if possible, as amputation is liable to lead to "crowding" of the other toes. Amputation of the 2nd causes the great toe to develop a valgus deformity.

(3) The great toe should never be hastily amputated. If even a small mobile portion can be saved, the foot will be a much more efficient unit.

Chest Injuries.

Contusions of the chest and fractures of ribs are daily occurences in pits. Falls of roof, props "jumping" and Sylvester accidents are the usual causes of these injuries. Very occasionally a fracture of a rib is caused by muscular violence, e.g. when lifting a heavy stone.

The symptoms of contusion and fracture are practically identical, though in simple contusions no tenderness is

elicited on antero-posterior compression.

The treatment of both injuries is identical.   The
chest is strapped around the base on expiration.   The
strapping is carried completely around , as advised by
Bohler (Ref. 29), a method which in the author's experience
is very efficacious.   If an upper rib (1 - 4) is involved,
circular strapping around the base is combined with
strapping extending up across the nipple area, over the
shoulder and down to the circular strapping on the back of
the chest.

Complications.   By far the most common and serious complication
is an acute bronchitis following the injury.   This is
frequent in the older miner, and for several days distress
is acute.   The treatment of this condition entails rest
in bed, with the patient propped up.   If there is severe
pain at the fracture site, 2% novocain should be injected
to block the appropriate intercostal nerve.   The chest is
strapped.   If the sputum is scanty and viscid, and the
cough irritable and non-productive, Pot. Iodide in small
doses (gr. 2 - 4) t.d.s. should be given.   Oxygen given
by means of the "Spectacle" method is very useful if
cyanosis is marked.

When the sputum becomes more fluid, a stimulating
cough mixture with Ammonium Carbonate and Tinct. Nux Vomica
is excellent.

If there is any suspicion of pneumonia, Sulphapyridine,
or the newer and less toxic Sulphamezathine is prescribed,
but most cases follow the course of a bronchitis and

consolidation is rare.

<u>Injury to the Lung</u> is rare.   Surgical emphysema calls
for no special treatment unless it extends upwards and
leads to pressure on the great veins.

<u>Haemoptysis</u> is seen occasionally, and calls for rest
in bed, strapping and Morphia.   The latter may be prescribed
as Syrupus Codeinae Phosphatis ʒ1 - 2 t.d.s.   This is a
valuable sedative in such cases, as the cough is relieved,
without producing any depressing effect.

Fractures of the Pelvis.

Each year about half a dozen fractures of the pelvis
are seen by the writer, and, although the number is not
great, treatment is important, as poor reduction of these
injuries leads inevitably to chronic pain and disability.

The violence is usually of the nature of crushing,
e.g. a heavy stone falls on a man and rests on his pelvis,
or a boy is caught between two tubs.   Shock and pain are
marked, and efficient first aid treatment is of great
importance.   Transport underground of such injuries is of
necessity difficult and trying.

<u>Avulsion Fractures.</u>

No avulsion fractures have been seen in miners.

<u>Isolated or Segmental Fractures.</u>

(a) <u>Fractures of the Ilium</u> - either fissure fractures ,
or segmental are seen occasionally.   In the fissure fracture
with no displacement, no treatment other than rest in bed
and the application of a binder is necessary.   Where a

segment of the ilium is detached, even if it is displaced,
rest in bed is sufficient.   The writer has on one occasion
attempted by means of a Steinmann's Pin driven into the
fragment, to improve the position of an isolated fragment,
but the result was disappointing.   The patient made a
complete recovery.   Union of such a fragment is rapid and
weight-bearing can be allowed in 5 weeks.

(b) Fractures of the Pubic Rami.

Where there is a fracture of one or both Rami with no
displacement, i.e. where the symphysis pubis is not disrupted
treatment is carried out as in (a).   The prognosis is
equally good.

(c) Minor Separation of the Symphysis Pubis.

This injury is looked on with great suspicion.   The
writer has frequently noted in these cases marked tenderness
over the ipsi-lateral sacro-iliac joint, and, even without
x-ray confirmation, regards such a case seriously.

It seems that many of these so-called "minor"
separations may have been "major " separations at the time
of injury, and the displacement is partially corrected by
the time x-ray examination is carried out.

Accordingly, it is considered advisable in all so-called
"minor" separations to make a careful examination of the
sacro-iliac joints.   If there is local tenderness, the case
is treated as a serious injury, and the pelvis immobilized
in plaster for 3 months.   Watson Jones' method of reduction,
by placing the patient with the sound side of the pelvis
on a pelvic rest and pressing the ilium forwards and

downwards, has been found very effective.   (Refs. 52 and 53).

In several of these injuries, severe tympanites has been noted.   One patient - a strong healthy miner of 36 - was acutely distressed.   Vomiting was not a feature, but the gaseous distension of the bowel was alarming.   Simple Enemata, and Enemata with Turpentine, gave no relief. Pitressin, given in a dose of 0.5 c.c. on the first day, then 0.4 c.c., then 0.3 c.c. etc. for five days produced a dramatic change, and after seven days the abdomen was normal.

Combined Fractures.

(a) In lateral crushing injuries both pubic rami - superior and inferior - may be fractured and the symphysis dislocated.   This injury is relatively common, and as the displacement is usually small, and is not increased by normal rest in bed, no more elaborate treatment than recumbency for 6 - 8 weeks is necessary.

Asimilar injury, but less frequent, is the bilateral fracture of both pubic rami.   The attachment of the rectus abdominis, oblique abdominal muscles, adductors of the thigh, pectineus etc., all combine to stabilise the fragment and displacement is, as a rule, slight.   (See Fig.62).

FIG. 62.

Bilateral Fracture of both pubic rami.

A serious complication is rupture of the urethra.
(Ref. 54).   This has been met with on four occasions with
this type of fracture.   In three, the rupture was external
to the triangular ligament, and in the fourth the
rupture was intrapelvic.

In the bulbous injuries it was possible, in one case, to
approximate the torn urethral ends and unite them with fine
catgut.   Despite this a stricture developed and this
patient still requires bougies once every six months.   In
the other two, the extravasation of blood was so extreme,
and the oozing of blood so persistent, that it was
impossible to find the proximal end.   A suprapubic
cystostomy was made and retrograde passage of a bougie allowed
a "penile" bougie to be passed into the bladder.   A

catheter was tied on to the point of the bougie and withdrawn gently along the urethra.   One of these cases healed without any stricture, but the other has a typical resilient stricture requiring regular attention.   One case (with a stricture) is now working at the coal-face, and has no complaints.   He reports with great regularity every six months for bougies.   He has no grouse!

The Intrapelvic rupture was explored from within the bladder and through the space of Retzius.   It was impossible to see the tear and one had rapidly to perform the "two bougie manoeuvre", thus enabling the penile bougie to pass into the bladder.   A de Pezzer catheter was attached to the tip of the bougie and withdrawn. Convalescence was stormy and on the fourth day the patient, in a maniacal fit, pulled the de Pezzer catheter out !   Apparently he did no damage, as a soft rubber catheter was inserted thereafter with ease.   He is now well and has no stricture !

(b) In antero-posterior crushing, the force acting on the two halves of the pelvis, forces one side apart from the other - hence the type with disruption of the symphysis pubis and a fracture of the ilium near the sacro-iliac joint, or dislocation of the sacro-iliac joint.

FIG. 63.

Sacro-Iliac
Dislocation.

Symphysis
Pubis
Dislocation.

Dislocation of Symphysis Pubis and Sacro-Iliac Joints.

Note the osteo-arthritic change in the Lumbar Spine.

The weight of the leg acting on the displaced fragment
tends to maintain the position.

This type is not seen frequently, but it is met with
when a man is crushed between heavy tubs. Shock is very
severe. The leg on the affected side of the pelvis lies
in an externally rotated position, and any movement of the
limb causes severe pain.

The method devised by Watson Jones (Ref. 52) for
reduction of these dislocations is a great advance.
Previously, the writer had adopted hammock treatment with
extension to the affected limb (Ref. 29). But the
simplicity and efficiency of reduction in the lateral
position has quite altered the prognosis in these cases.

A general anaesthetic is necessary.   The patient is placed with the sound side of the pelvis resting on the pelvic rest of a fracture table.   The dislocated fragment is now uppermost.   The ilium is grasped , rotated and pressed forwards.   A useful clinical guide is the reduction or otherwise of the gap between the pubic bones.   An x-ray is taken and if the position is judged to be satisfactory, a double hip spica is applied.   This plaster must fit accurately over the pelvis, and hence the iliac crest and anterior superior spine must be well protected with felt.

It is necessary to continue immobilization for at least 12 weeks.   Despite painstaking and remarkably accurate reduction, the author has noted that in some of these cases a persistent complaint of aching in the region of the affected sacro-iliac joint.   In one case there is definite radiological evidence of arthritic change, but this patient has declined a fusion operation.   In another, careful x-ray examination has failed to show any mal-position or arthritis.   The question of arthrodesis is still sub-judice: it is hoped that if this is carried out, he will be relieved of his pain.

In two cases - one under treatment at present - an associated rupture of the bladder was present.   One case, treated two years ago, had a double rupture of the bladder, one intraperitoneal and one extraperitoneal.   The bladder ruptures were sutured, but the patient died 24 hours later of profound shock.

The case under treatment at present had a single extraperitoneal rupture, with extravasation of urine. The bladder was sutured within 7 hours of the injury. He has made an excellent recovery. See Fig. 64.

FIG. 64.
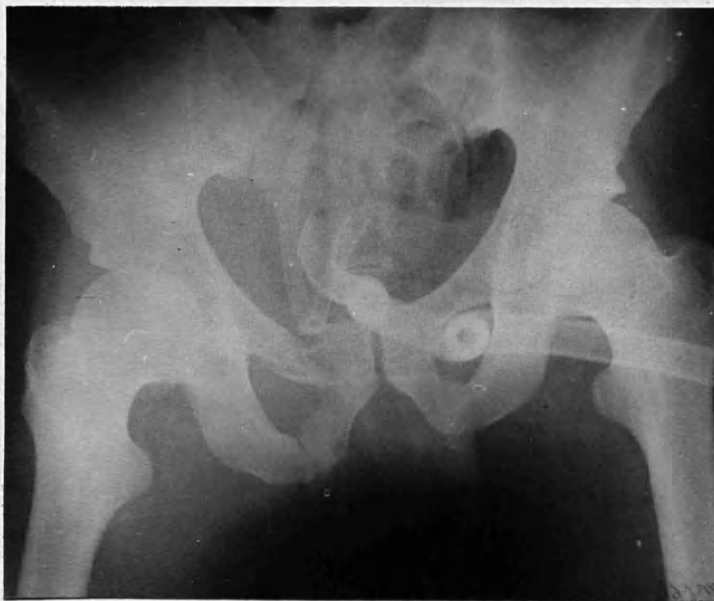
Fracture of Pelvis with Rupture of Bladder.

A case seen recently by the author presented some unusual features, and is an excellent example of the very gross nature of colliery accidents. The injury occurred when a fall of stone struck a stooping miner on the lower lumbar region and the back of the pelvis. He was admitted to hospital in great pain, despite $\frac{1}{4}$ gr. morphia administered in the pit. Two fingers could be inserted between the pubic bones at the symphysis; and the entire posterior pelvis, sacrum and lumbar spine was so tender that no further accurate information was obtained. There was no

evidence of visceral injury and he was able to micturate

freely.   X-ray had to be delayed for 48 hours.   See
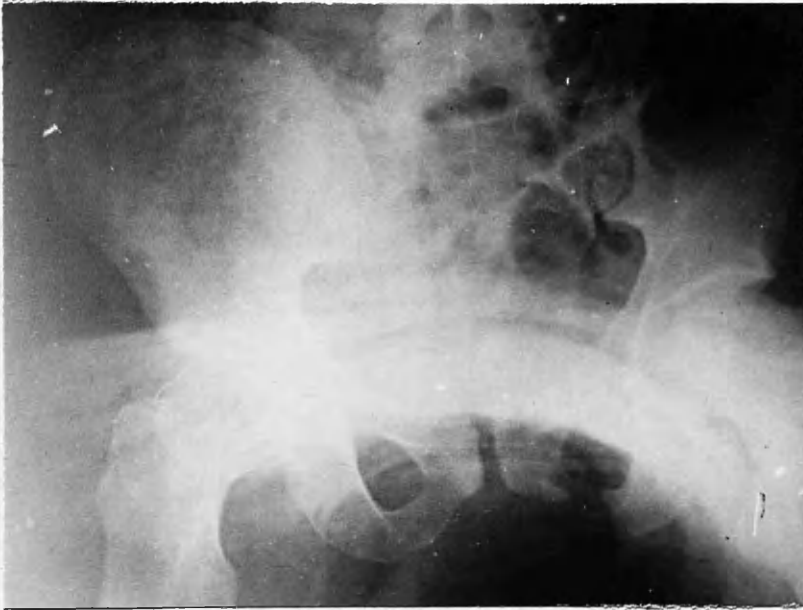
Figs. 65, 66 and 67.

FIG. 65.

Pre-reduction X-ray.
(See description p. 151).

FIG. 66.

X-ray taken on the operating table showing reduction
of symphysis pubis.

FIG. 67.

Later X-ray (through plaster) showing excellent
reduction.

The x-rays showed the following lesions :-

(1) Lumbar spine - fracture of the R. transverse process of
the 2nd lumbar vertebra,

(2) Dislocation of L. half of pelvis - the pubic bones being
separated by about 1" at the symphysis,

(3) The L. sacro-iliac joint appeared normal, but there was
a fracture of the lateral mass of the sacrum, passing
obliquely down and out, involving the sacro-iliac joint,

(4) The R. ischial tuberosity showed a fracture line
extending upwards to the acetabular region and involving
the hip joint.   There was no displacement.

This complicated fracture dislocation of the pelvis
was reduced by placing the patient on his <u>L. side</u>, that is ,
on the dislocated half of the pelvis.   It was considered

inadvisable to place him on the R. side, as the weight transmitted through the head of the femur might conceivably have caused displacement of the fractured acetabulum and ischium - especially as the symphysis was unstable.

Central Dislocation of the Hip with Fracture of the Pelvis.

The writer has dealt with three such cases.

The history was the same in each case - severe violence to the area of the great trochanter caused, by falls or (in one case) by a tub.

The x-ray appearance in all cases was practically identical :-

(1) The fracture line ran through the upper third of the acetabulum,

(2) The fracture line extended obliquely from the acetabulum upwards above the pectineal eminence,

(3) The superior pubic ramus and the ileo-pectineal eminence were driven inwards away from the ilium,

(4) The head of the femur followed the displaced fragment.

FIG. 68.

Central Dislocation of the Hip with Fracture of Pelvis.

<u>Treatment.</u>   All cases were treated by continuous extension with the leg abducted.   A Steinmann's pin was driven through the tibial tuberosity and the leg suspended in a Bohler-Braun frame.   Rapid restoration of the normal position of the femoral head was obtained, but in no case was the acetabulum restored to normal.   Two cases - one seen four years ago, and one two years - have developed gross osteo-arthritis and, as both are elderly men, they are completely disabled as far as mining is concerned.   One case is under treatment at present, and, unfortunately, it appears that this man likewise will develop arthritis. As he is a young man, an arthrodesis will probably be advised.

The injury is not common, but it is extremely serious. Whether, as Diggle says, it is possible to restore the acetabulum by open reduction or no, it appears that the damage to the joint is so gross that arthritis is probable in any event .   (Ref. 55).   It is the author's intention, however, when a similar case is met with again, to explore the acetabulum by an extraperitoneal approach and attempt to reduce the fracture accurately.   If this is successful, then the pelvis will be immobilized in plaster, and continuous leg traction maintained for 10 - 12 weeks in an effort to prevent arthritic change developing.

C. Gordon Irwin, in a recent conversation, indicated that he was very pessimistic about open operation in any way preventing arthritis. (Ref. 56).

However, Levine (Ref. 57) claims that he has been successful with open operation in one case.

The accompanying x-rays show the progressive degeneration
of the hip joint in one such case.   See Figs. 69 and 70.

FIG. 69.

FIG. 70.

Fractures of the Spine.

Undoubtedly the most characteristic injury met with
in coal mines is the fractured spine, and by far the commonest
region affected is the lumbo-dorsal region - 12th dorsal to
2nd lumbar - the region where the relatively immobile
thoracic spine joins the mobile lumbar segment.   Cervical
injuries are, by comparison, rarities and do not call for
detailed consideration.

(1) Fractures of Spinous processes are, surprisingly, seldom
seen.   In the last two years the author has only met with
one case.   The spinous process of the 1st thoracic vertebra
was broken by a fall of stone.   Pain was severe, and
disability was complete.   Rest in bed for one week was
followed by ambulatory treatment, with local strapping.
A rapid recovery of function ensued, but persistent pain
was troublesome.   After considerable hesitation, the
fragment was removed and within four weeks the patient was
back at work.

So called "Clay Shovellers" fracture has not been seen.
This is noteworthy, considering the amount of shovelling
necessary in coal-mining.

(2) Fractures of Lumbar Transverse Processes.

(a) Avulsion fractures of several transverse processes, caused
by strong contraction of the quadratus lumborum, are
seldom seen.

(b) Fractures caused by direct violence - usually falls of
roof - are frequent.   The local signs are marked -
bruising, swelling and haematoma formation, and very

acute local tenderness are the cardinal signs.   Associated injury to the kidney is met with, but rupture of the spleen has not been encountered.

X-ray diagnosis is difficult, as in many cases the lumbar transverse processes are obscured by bowel shadows, and it is often necessary to prepare the patient before obtaining satisfactory radiographs.   The transverse process of the 2nd lumbar vertebra is most frequently affected.

Treatment.   In the type where one transverse process is fractured by direct violence, the patient is rested in bed for 7 - 14 days.   The back is then strapped with elastoplast or adhesive plaster and ambulatory treatment commenced.   If pain is relieved, graduated spinal exercises are commenced.

Multiple fractures caused by muscular violence are treated by rest in bed for 2 - 3 weeks, followed by strapping.   But if pain is severe, a plaster jacket applied for 5 weeks is more satisfactory.

It is unusual for these fractures to unite by bone, but this does not prevent a complete functional recovery.

The writer's experience is based on the isolated direct violence fracture, and the results are, on the whole, excellent.
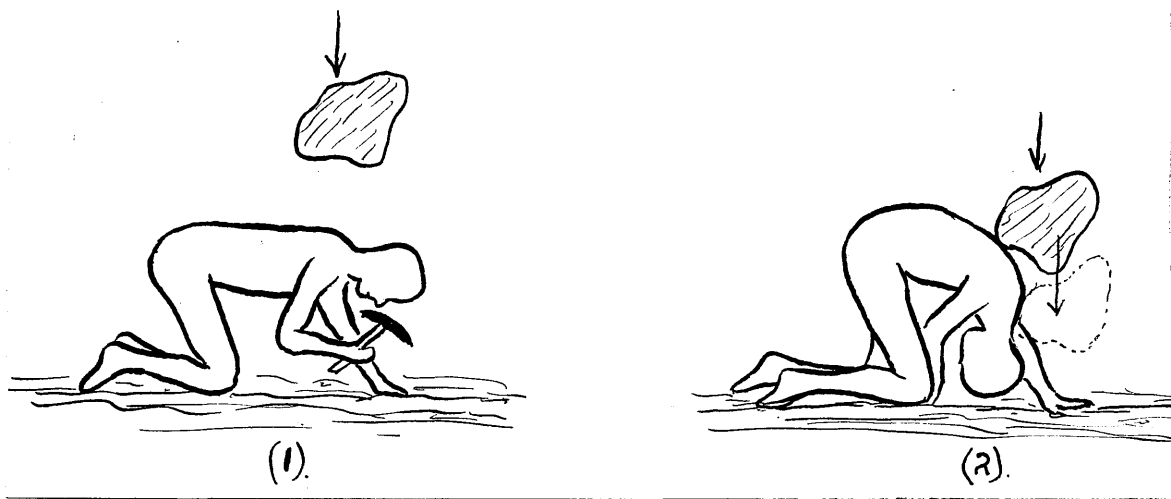
(3) Fractures of the Lumbo-Dorsal Spine (without cord Injury).

This injury is, unfortunately, almost a daily occurence. The miner, working in a stooping position, is struck by a fall of stone.   The stone, landing between the shoulders,

doubles him up, so that his head approximates his knees.
See Fig. 71.

FIG. 71.

Showing Mechanism of fractures of the spine in Miners.

History.   In all back injuries a few minutes spent in
taking a careful history is of great value.   The patient
cannot demonstrate, but the surgeon can demonstrate for
the patient.   A clear idea of the violence is thus obtained
and a presumptive diagnosis arrived at.

Examination.   As these patients are often cold, shocked
and in pain, it is advisable to delay examination for a few
hours.   Response to simple anti-shock treatment is rapid.

Method of Examination.

(a) History.

(b) Rapid palpation of chest wall and sternum.   Any
      local sternal tenderness and deformity suggests a
      very severe spinal injury.

(c) Rapid abdominal examination.   The patient often

complains of abdominal "soreness".

(d) Pelvis: perineum for haematoma;   external urinary
meatus for blood.

(e) Ask the patient to move his feet or toes.   Test
sensation of feet and legs.

(f) Ask the patient which side he would prefer to be
turned on to: usually he has a "good" side.   The
patient puts one arm round the sister's neck: the
sister places one hand over the upper thoracic region:
the nurse or house surgeon controls the pelvis and
a third person the legs.   By order, the patient is
then rolled over, firmly yet gently.

(g) Rapid inspection of the spine is made and any
swelling noted.   A central diffuse swelling is
strongly suggestive of fracture.   Any acute gibbus is
obvious.   Palpation of the spinous processes reveals
acute local tenderness over the affected vertebrae
in 60 - 70% of cases.

Palpation of the transverse processes, ribs and
pelvis completes the examination.

The patient is then rolled back.

(h) X-ray examination follows.   Transporting the patient
is best effected by rolling him on to a stretcher
cover, inserting long poles and fixing the poles by
means of two distance bars.   The A.P. x-rayis taken
first and then the very important lateral view.
Good lateral x-rays are very essential.

(A) <u>Simple Wedge Fracture of one or more Vertebrae.</u>

In the minor degrees of this injury, it is easy, on clinical examination, to miss the injury.   Often there is no haematoma, no angular deformity and very slight tenderness, and consequently x-ray examination may be omitted.   The important point is the history.   In all cases where a spine has been forcibly flexed, a provisional diagnosis of fracture must be made until x-ray examination proves this wrong.   It is a common occurence for the writer to see cases of "lumbago" developing 2 - 4 - 10 years after an accident.   When the history is gone into, it transpires that the injury was a fall of stone on the shoulders and that he was "doubled up".   X-ray shows a typical Kummel's Disease i.e. a missed fracture of one or more vertebrae.   Hence the author instructs all house surgeons to assume a fracture in all such cases and to proceed to x-ray examination. The damage is often minimal; the depth of the anterior edge of the vertebral body is reduced by a sixth or a quarter inch, and often two or three are similarly affected. There is no comminution, and no intervertebral disk injury. In some cases there is difficulty in giving an opinion as to the presence of a fracture or no.   In such a case, if there is (1) any loss of depth of the body anteriorly, (2) any increase in the concavity of the anterior edge of the body (lateral x-ray) and (3) if there is a definite history of sudden flexion, then the author advises that the case be treated as one of fracture.

The prognosis is relatively good, but see Table 24, p.174 .

<u>Reduction</u>.   In all lumbar and lower thoracic wedge fractures,
reduction is effected by the method of hyperextension (Watson
Jones).   The writer has followed Bohler's technique (Ref. 29)
of injecting 2% Novocain where there is a well marked
haematoma.   W. Jones is of opinion that this is unnecessary,
but experience shows that it is very valuable in relieving
local pain and in obtaining good hyperextension.   The trunk
is then covered with a double layer of circular stockinet
and the patient placed between two tables in the well-known
method of W. Jones.   It is important to stress the position
of the pelvis in relation to the lower table: the pelvis must
be free of the table, and this permits excellent sagging
of the abdomen i.e. hyperextension of the spine.   The
writer assists the patient by putting slings around each
arm close to the shoulder and these slings are held by an
overhead pulley.   See Fig. 72.

FIG. 72.
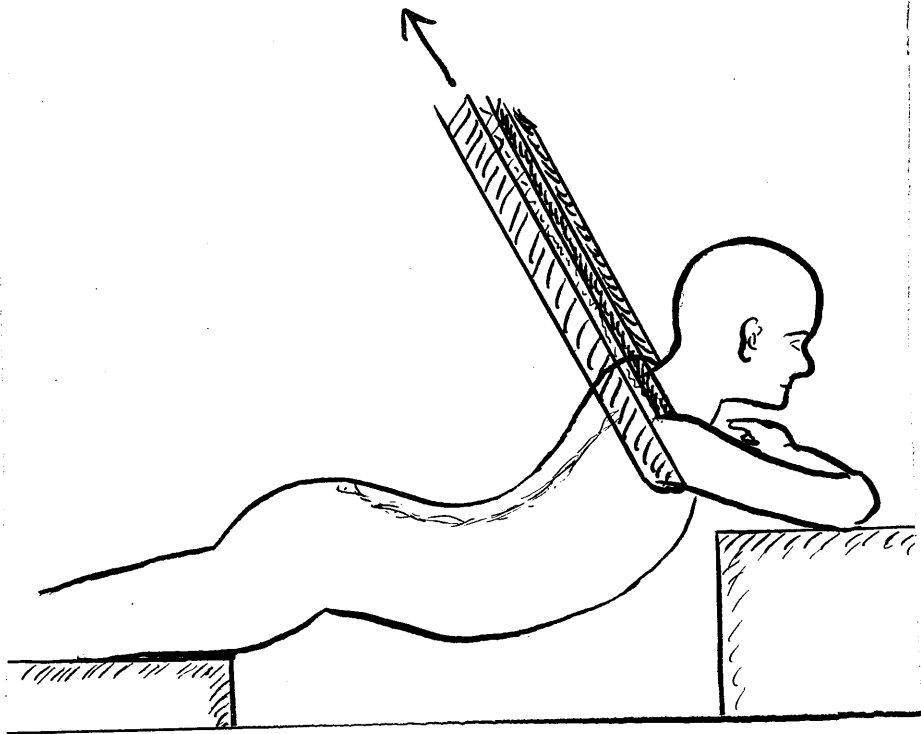
Position for reduction of Lumbo-dorsal Fractures.

The patient is reassured and a nurse is detailed to stand at the patient's head to help and encourage. Despite all that is said to the contrary, the ordeal is often very trying.

The legs are tied to the small table. The stockinet is carefully adjusted to avoid any creases: adhesive felt is applied over the anterior superior iliac spines and over the site of the fracture. The "team" should now be ready. A team consists of (1) a nurse in charge of the plaster bandages and slabs, (2) a nurse at the patient's head, (3) a porter, (4) an assistant and (5) the surgeon. The surgeon stands at the patient's left side, the assistant at the right side. Using wide 6" or 8" bandages, the

trunk is rapidly covered with circular bandages.   Using
slabs made from 4" bandages, a central slab is applied
anteriorly from the upper sternum to symphysis, two lateral
slabs from the axilla downwards, a horizontal slab across
the top of the plaster in front, and one across the symphysis
pubis.   The slabs are now "anchored" with 6" bandages
applied "wet and sloppy".   The whole is carefully moulded
and "rubbed in" so that the plaster becomes, as it were,
one solid piece.   The plaster is finally examined for any
weak spots.

Trimming is carried out and a 2" flap of stockinet is turned
over and fixed with a plaster bandage.

A good plaster must fulfil the following conditions :-

(1) It must be strong,

(2) It must be comfortable,

(3) The plaster must extend from symphysis pubis to
    upper sternum and medial half of clavicles,

(4) The plaster, posteriorly, extends up to the lower
    edge of the scapulae.

When the plaster is firm, the patient is lowered face
down on to a table with pillows under his thighs and chest.
After a few minutes he can return to bed.   A window is <u>not</u>
cut as a routine and it must certainly never be cut within
24 hours.   A check x-ray is taken.

Within 48 hours the patient is allowed up.   Post
reduction abdominal pain is common and is treated by
Pituitrin $\frac{1}{2}$ - 1 c.c. and a Flatus Enema.

As soon as the patient is up he commences exercises.

Such exercises are graduated carefully, bearing in mind the
patient's age.

It is remarkable how well plaster jackets are tolerated.

FIGS. 73 - 80.

Two elderly miners convalescent following fracture
of the spine.

Mobilisation exercises after removal of plaster jacket.

Advanced
Mobilisation
and Muscle-
Building
Exercises.

Difficulties.

(a) Age.   The older the patient, the more difficult is
reduction.   Hyperextension is often poor, and, as a result,
reduction is not perfect.   In such cases, a second attempt
has to be made, and , even so, it may not be possible to get
a satisfactory reduction.   The position then has to be
accepted.

(b) Chest Complications contraindicate any attempt at reduction.
The patient is nursed with the head of the bed raised.
Reduction can still be effected satisfactorily up to a period
of 21 days.

(c) Other Injuries.   The writer has met with the following :-
    (1) Flexion fracture of 1st lumbar, with associated
        fracture of the tibia.   The tibia was reduced and
        fixed in plaster, and thereafter the spine was treated.
    (2) Flexion fracture of the 12th thoracic, with associated
        torn medial cartilage.   The cartilage was left until
        the spine was treated.
    (3) Flexion fracture of the 12th thoracic with fractured
        rib.   The rib was strapped and treatment of the
        spine was delayed for 14 days.

(d) Unsatisfactory Reduction.   It is an axiom that reduction
must be as perfect as possible.   This is not always obtained,
and in some elderly miners, with osteo-arthritic spines, it
is simply impossible to obtain satisfactory hyperextension
and consequently reduction is incomplete.   It may be, in
such cases, that the postion should be accepted and no

further attempt made.

But, in younger men, an unsatisfactory position should not be accepted. After a few days, another attempt at reduction should be undertaken. In several of the writer's cases, three reductions have been necessary.

(e) Delayed Treatment. Where for any reason, treatment has to be delayed, the problem is much more difficult. If the delay is not more than one month, an attempt at reduction by hyperextension should be made; but if this is unsatisfactory, then a second attempt, under full anaesthesia , using Davis' technique (ankle suspension) should be made. . (Ref. 58).

If it is impossible to effect reduction satisfactorily, it is imperative to apply a plaster jacket to prevent further collapse of the vertebra. Such unreduced fractures lead to persistent pain and aching, and arthrodesis may be necessary.

(B) Comminuted Fractures. (See Figs. 81, 82 and 83).

FIG. 81.

Comminuted Fracture showing severe crushing of the
vertebral body.

FIG. 82.

Comminuted Fracture showing fragment detached from the
upper anterior part of body.

There is marked tendency to bony fusion between the
affected vertebra and the one above - a natural arthrodesis -
proof that the intervertebral disk has been damaged.

(C) **Flexion Fracture** of Thoracic Spine.

Fractures of the thoracic spine are rare injuries,
constituting about 6% in the author's experience.   Often
two or three vertebrae are affected simultaneously, each
body showing a minor wedging deformity.   There is usually
no kyphus.   Reduction is extremely difficult, and,
fortunately, does not appear so important as in lumbo-dorsal
fractures.   The writer, so far, has never been successful
in obtaining 100% reduction in any of these cases - yet
the results are good.

Reduction is attempted by elevating the spine at the
level of the fracture by means of a kidney bridge, or by
suspension of the patient with a strong webbing strap
attached to an overhead pulley. See Fig. 84.

<p align="center">FIG. 84.</p>
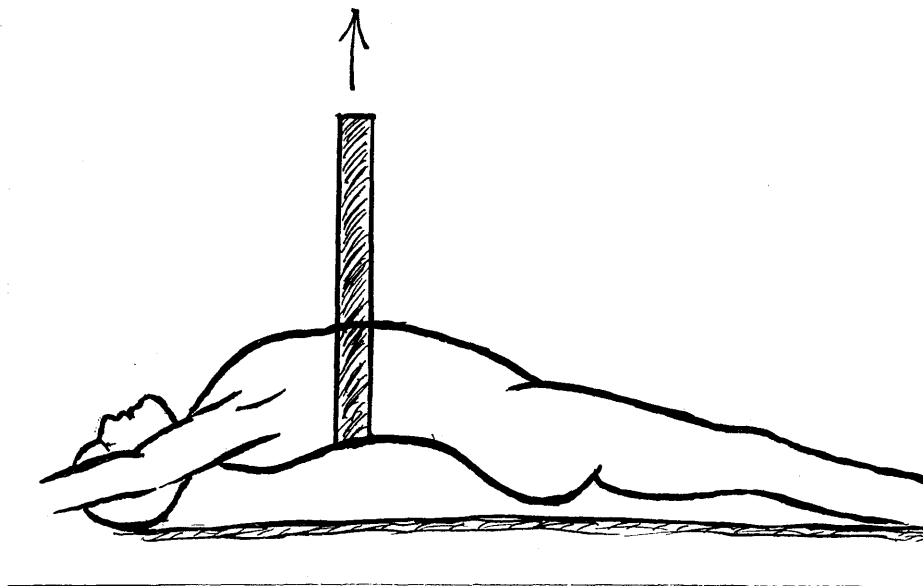
A plaster jacket is applied.

(D) <u>Fracture Dislocation.</u>

About 10% of fractured spines in collieries come within this category.

The dislocation occurs immediately above the fracture, i.e. if the 2nd lumbar vertebra is fractured, then the 1st lumbar vertebra is dislocated forwards.   To allow of dislocation the neural arch must be fractured, or the interarticular joints dislocated.   As the vertebra passes forward, the cord is caught by the upper posterior edge of the fractured vertebra, (See Fig. 85), and consequently paraplegia is frequent.

<p align="center"><u>FIG. 85.</u></p>
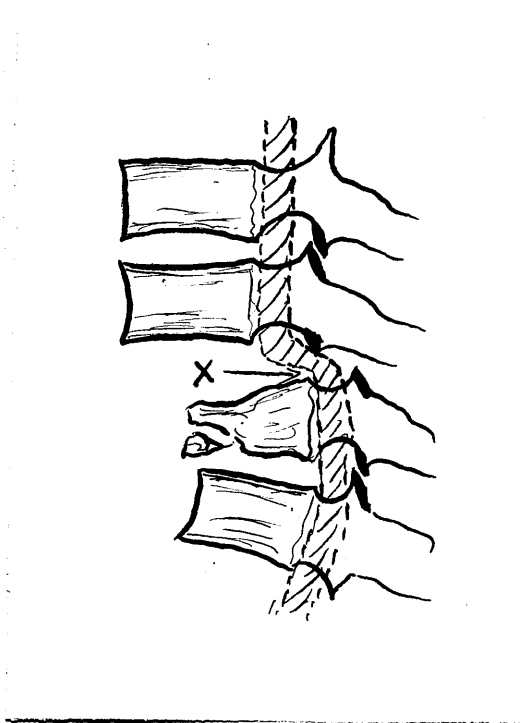
In such cases a careful examination of the x-ray plate is necessary to exclude inter-locked articular processes (Ref. 59), as this type cannot be reduced by hyperextension. The usual fracture dislocation with fracture of the laminae reduces remarkably well by hyperextension, and the writer has always favoured an attempt at reduction as soon as possible.

Unfortunately, it is rare in these cases to see a complete recovery of the paraplegia, but each case must be given a chance. The prognosis in lumbar fracture dislocations affecting the cauda equina is better, and slow recovery has been noted over a period of a year. In fracture dislocations of the thoracic spine, the prognosis is grave, as the narrowness of the vertebral canal here means probable total section of the cord.

In all cases, lumbar and dorsal, the writer reduces the fracture by the Davis technique and rapidly fashions a posterior plaster bed. This is carefully lined with felt. A Steinmann pin is driven through each tibial tuberosity and the patient lies in bed with both legs suspended in a Bohler-Braun frame, with 15 lbs extension applied to each leg. A suprapubic cystostomy is performed and the patient is given a course of sulphathiazole to prevent urinary infection. By this means bedsores are prevented and nursing is eased.

Experience shows that in all thoracic fracture dislocations with clinical evidence of complete cord section, the chances of recovery are very poor. In the lumbo-dorsal segment, the chances are considerably brighter. One case

with incontinence of faeces and urine and paralysis of both legs, made a remarkably recovery. The paralysis cleared up in one leg completely, and in the other leg as far as the knee joint. Micturition became normal, but the bowel action remained precipitate.

In another, with a slight cauda equina lesion, complete recovery ensued, after an open reduction of a most gross dislocation. It is contended, therefore, that all should be given a chance. In any case, where, after 3 - 4 weeks, no sign of recovery is shown, the plaster bed etc. is removed and the case looked on as one of permanent paraplegia. One such case known to the writer is alive and well 20 years after his injury. Despite his grievous disability, he retains a great zest for life and finds great joy in reading and in music.

Fracture Dislocations with Interlocked Articular Processes are now well recognised. (Ref. 59).

The writer has operated on five such cases. In four, complete paraplegia was present and no recovery was seen despite accurate and easy reduction following removal of an articular process. The fifth case had no nerve symptoms, and reduction was effected easily. The 3rd lumbar vertebra was severely comminuted and the 2nd intervertebral disk ruptured. Recent x-ray shows a solid mass of bone uniting the 2nd and 3rd vertebrae.

Assessment of Final Results.

Probably, in the last ten years , there has been too much optimism over the end results of the treatment of

fractured spines.   Certainly no one doubts that the study of these cases, and of the factors concerned in reducing the deformity, has placed us in a much more satisfactory position to meet them rationally.   Careful follow up has enabled one to prognosticate - with some accuracy - yet, despite the advances in treatment, in the coal trade at least, the injury constitutes a most serious handicap for the unfortunate man, and the end results are such as to make one, at times, depressed.   In the following tables, a consecutive series of 50 fractures of the spine under the writer's care has been analysed, and the figures given speak for themselves. The problem is a grave one, and much remains to be learned :-

TABLE 21.

Total No. of Fractured Spines	50.
Average Age	39.
No. died as a result of injury	1.

TABLE 22.

Analysis of 50 Fractured Spines according to the site of fracture :-

	Vertebra.											
	Th.7	Th.8	Th.9	Th.10	Th.11	Th.12	L.1	L.2	L.3	L.4	L.5	Two or more
No.	1	1	-	1	2	9	10	12	5	2	2	5

TABLE 23.

Classification of 50 Fractures of the Spine according to the type of injury :-

Simple Wedge Fractures	Comminuted Fractures	Fracture Dislocations	
		With Paraplegia	Without Paraplegia
30	15	4	1

TABLE 24.

Analysis of 30 Simple Wedge Fractures :-

Total No.   30.
Average age   40.

Result	No. & %	Average Age	Average disability Period in days before resuming work stated.
Permanent Total Disablity	1 (3.3%)	54	Permanent
Permanent Partial Disability	16 (53.3%)	42	186
Complete Recovery	13 (43.3%)	35	190

TABLE 25.

Analysis of 15 Comminuted Fractures :-

        Total No.   15.
        Average Age   39.

Result	No. & %	Average Age	Average disability Period in days before resuming work stated.
Permanent Total Disability	1 (6.6%)	56	Permanent
Permanent Partial Disability	8 (53.3%)	48	228
Complete Recovery	6 (40.1%)	32	398

TABLE 26.

Analysis of 5 Fracture Dislocations :-

        Total No.   5.
        Average Age   33.

Result	No. & %	Average Age	Average Disability Period in days before resuming work stated.
Permanent Total Disability (including 1 death)	3 (60%)	34	Permanent
Permanent Partial Disability	2 (40%)	33	360
Complete Recovery	0 (0%)	-	-

TABLE 27.

Analysis of all cases in relation to post-accident

working capacity in Coal Mines :-

No. making such a recovery that they were able to resume full work	19
No. so disabled that they were fit for light work only	26
No. so disabled as not to be able to resume any colliery work	4
No. dying as a result of the accident	1
TOTAL	50

It is very obvious that the accident must be looked on
as most serious and there is no ground for complacency.
Much work and research remain to be done.   Should severe
comminuted fractures be reduced and arthrodesed at once ?
Or should the plaster jacket be retained for 6 - 8 months
in the hope that a natural arthrodesis will result ?

Even the simple wedge fractures disappoint.   Why
should a man with a minor wedging of a vertebra, so perfectly
reduced as to be scarcely recognizable on x-ray examination,
complain of aching pain at the site of fracture ?   Arthritic
change explains some, but not all by any means;   and the
solution remains to be found.   The fracture dislocations
with complete paraplegia must be accepted as hopeless,

but, though only too frequent, they do not constitute the main part of the problem.   Some cynics observe that, if a fractured spine is "missed", and the man returns to work in a few weeks, he does not suffer from the aching pain of the treated fracture case.   There is some truth in this, but experience proves that these "missed" cases ultimately come for treatment for "lumbago" and x-ray reveals a crushed vertebral body - Kummel's Disease.

There are many psychologic factors involved, and the writer feels the problem acutely when he instructs all in attendance never to mention "fracture of the spine", yet all sorts of lay people, trade union officials etc., etc., talk glibly about so and so with a fractured spine.   The mention of fracture of the spine still connotes a sombre and terrifying injury to many lay people.

If all concerned could cooperate in the treatment of these cases in such a way as to let the patient see that his injury is one that he is expected confidently to recover from, much good would result.   The "handling" of the patient thus becomes a matter of great importance: the firm, cheerful bearing of the attendants: the confidence of the nursing staff: the encouragement of the physiotherapists, and the refusal to indulge in a show of sympathy - all are needed in the restoration of the injured miner.

Fractures and Dislocations of the Cervical Spine.

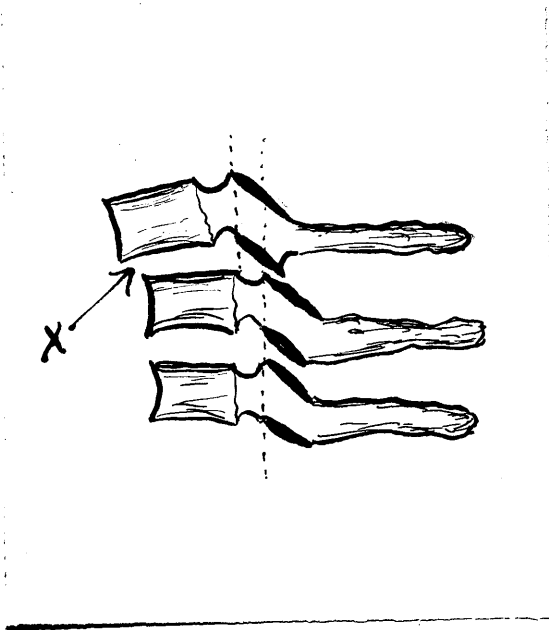These are remarkably rare in miners.

(1) Crush Fractures.   The writer has not met with any of these cases.

(2) <u>Subluxation of the Cervical Spine.</u>

Two cases of this type have been seen and both were caused by violence applied to the occiput.

X-ray shows a forward slipping of a vertebra on the one below, and the articular facets are not in normal relationship.   (See Fig. 86).

<u>FIG. 86.</u>
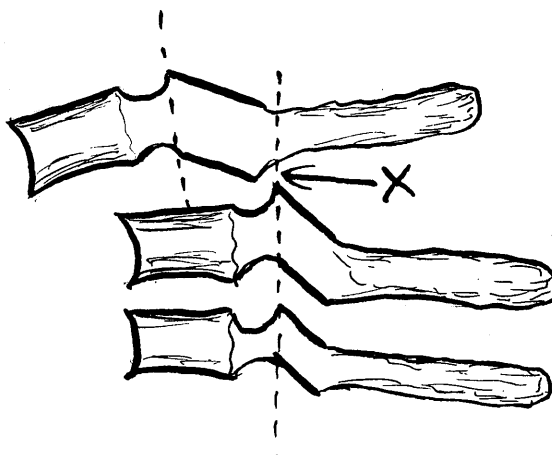

Subluxation of a cervical vertebra.

Reduction of such a subluxation is usually simple. The patient is placed on a table with a narrow padded board nailed to it, and extending about 18" beyond the end.   The patient is placed so that the end of the board is at the level of the subluxation and the spine (but not the head) is extended.   A check x-ray is taken, and if satisfactory, the head, neck and trunk are incorporated in plaster. A further x-ray is taken after the plaster has hardened.

To allow the capsule of the interarticular joints to heal,
a period of 8 weeks immobilisation is necessary.

(3) <u>Dislocation of the Cervical Spine.</u>

Only one case has been seen in five years.   The patient
walked out of the pit and walked home - a distance of three
miles!   He complained of pain and stiffness of the neck,
and tingling in both arms and hands.   X-ray showed a
complete dislocation of the interarticular joints.   (See
Fig. 87).

<u>FIG. 87.</u>

Dislocation of a cervical vertebra.

There was no demonstrable paralysis of the arms and
the leg reflexes were normal.

Reduction was attempted by means of a Glisson sling, but
this failed.   A skull caliper was applied under local

anaesthesia and initial traction of 15 lbs. applied.
Complete reduction - without any further manipulation - was
effected within an hour.   The traction was reduced to 10 lbs.
and was maintained for 3 weeks, when a plaster was applied.
The tingling of the fingers cleared completely.

Intra Abdominal Injuries.

It would be remarkable if the viscera escaped damage
when one considers the variety and severity of injuries to
which the miner is liable.   The writer does not propose to
discuss fatal visceral injuries such as occur in the
immediately fatal accident.

(1) Stomach.

One case of rupture of the stomach has been seen in
a boy of 15.   He was crushed between tubs.

The clinical features were those of profound shock,
haemorrhage and peritonitis.   Operation had to be delayed
for several hours.

Laparotomy revealed a 3" transverse tear of the
anterior gastric wall.   There was much blood in the abdomen
and extensive contamination with food.   The rent was
sutured in two layers and the abdomen drained by means of
a pelvic drain.   Despite energetic after-treatment, the
boy died within 24 hours.

(2) Duodenum.

A man was crushed between a tub and a taught wire rope.
On admission he was found to be severely shocked and to
present symptoms and signs of intra-abdominal haemorrhage.

After shock treatment, laparotomy was performed and the
following injuries were found :-

    (1) Two lacerations of the liver, one small and
         inaccessible near the portal fissure, and one near
         the fundus of the gall bladder,

    (2) A longitudinal flap laceration of the anterior wall
         of the duodenum. (See Fig. 88).

FIG. 88.
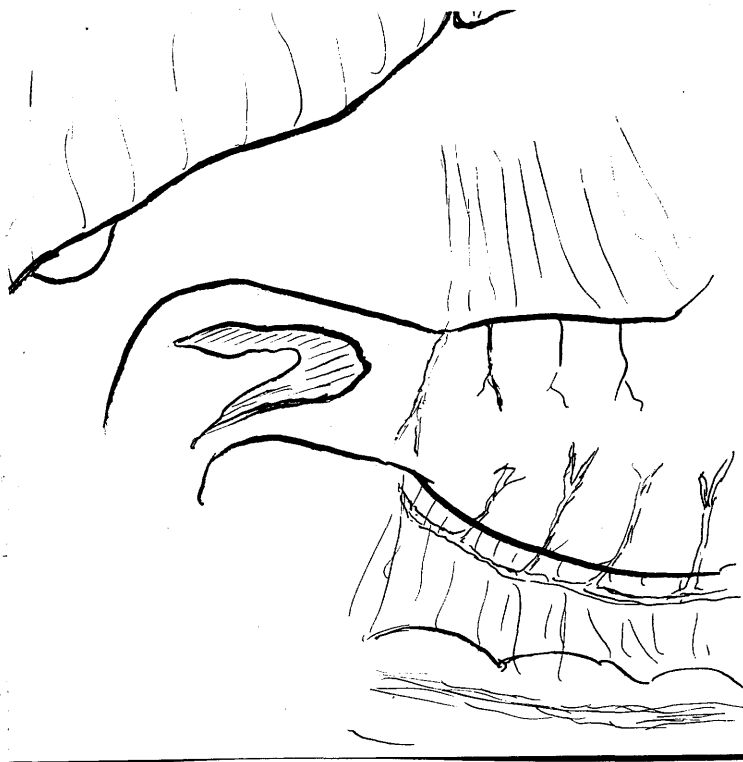
The anterior liver laceration was sutured with stout
catgut, and the bleeding was satisfactorily controlled.
The posterior laceration was difficult of access and a
pounded muscle graft was applied and two sutures inserted.
As these were considered insufficient, a gauze pack was
applied to the affected area.

The duodenal tear was easily repaired, and omentum
sutured over the area.

A pint of blood was given after operation by slow
transfusion.   Convalescence was remarkably smooth until,
on the 10th day, he had a gross haematemesis and died
immediately.   Post mortem examination was not carried out.

(3) Kidney.

In all, about 10 cases of injury to the kidney have
been seen, but in no case was nephrectomy necessary.
Treatment by rest, morphia and observation of the pulse,
was satisfactory.   The urine was put up in glasses at
regular intervals, as recommended by Bailey (Ref. 60) and
and by this simple method the progress of the haematuria was
observed.   One man developed clot retention and required
suprapubic drainage.

(4) Small Intestine.

A man was struck on the abdominal wall by a piece of
flying metal weighing 6 lbs.   The abdominal wall was
exquisitely tender and rigid, but some doubt was felt as
to the nature of the injury.   Observation for several hours
showed a rising pulse, so laparotomy was advised.

The findings were unusually interesting.   The right
rectus muscle was damaged and there was a considerable
haematoma within the sheath.   The parietal peritoneum had
ruptured and some blood had trickled into the abdominal
cavity.

On further examination a tear of the small bowel mesentery
was found, but fortunately this was parallel to the vessels

and the bowel was healthy.   The tear was closed without
incident and the abdomen closed.   He made an excellent
recovery.

(5) Bladder.

Two cases of rupture associated with fractures of the
pelvis have already been discussed (p. 148).

(6) Urethra.

This also has been discussed under "Fractures of Pelvis"
(p. 145).

(7) Colon.

No case of injury to the colon or rectum has been seen.

(8) Spleen.

It is a remarkable fact that the writer has yet to see
a case of rupture of the spleen in a miner.

(9) Biliary System.

A boy of 15 was crushed between tubs and on admission
complained of epigastric pain.   There was no rigidity.   He
was observed and no deterioration in his condition was seen
within 24 hours.   After 48 hours, some abdominal distension
was noted, and there was some dullness in the R. flank.
The pulse was normal and there was no sickness.   On the
4th day, jaundice appeared and the distension had increased
considerably; shifting dullness was noted.   Laparotomy
was advised.

The peritoneal cavity was found to contain about four
pints of bile-stained fluid.

The duodeno-jejunal flexure and duodenum were normal.
The gall bladder was soft, but contained bile and no rupture

was found.   There was no evidence of any injury to the common bile duct, nor was any haematoma of the gastro- hepatic omentum found.   The liver was examined carefully, and no rupture or laceration was discovered.

The gall bladder was drained and a second drainage tube was placed with the end at the portal fissure.

The abdomen was closed, with difficulty, as the peritoneum was extremely thin and the sutures cut out repeatedly.

Convalescence was very stormy.   Drainage from the gall bladder was not satisfactory and the jaundice increased. On the 9th day after injury, the boy died in coma.

Post mortem examination failed to reveal any adequate explanation of the biliary peritonitis.   Mr. Hedley Whyte (Newcastle) has informed me that he has met with a similar case.   (Ref. 61).

The Future.

The present is an unfortunate time to hazard a guess
as to the future of accident surgery: presumably the matter
will come within the scope of the Regional Hospital Authorities
as proposed in the Bill recently before Parliament . (Ref. 62).

However, certain observations can be made in the light
of the author's experience of existing practice, and criticisms
made in the hope that the future will see a new dispensation for
the urgent problem of accident surgery.

In making these criticisms, the writer refers to the
district of Northumberland only: conditions naturally differ
in other districts.

The Northumberland Coal Field extends in a relatively
narrow belt from north to south, close to the coast line.
Along the southern edge, the Tyne forms a natural boundary,
and on this boundary line Newcastle-on-Tyne is situated,
about 12 miles from the sea. Other than Newcastle, the
coal field boasts of no town of any size and importance,
and as a result there has been marked centralisation. This,
in the author's view, is not a good thing in accident work.
It is not at all likely that a miner, working in a pit 50
miles from Newcastle, will feel disposed to travel that
distance because he has sustained an injury to his thumb.
Yet, as everyone knows, such an injury - laceration,
fracture etc. - is of the greatest economic importance to
the patient and the country, and inadequate treatment may
cause prolonged and possibly permanent disability.

Hence the writer's opinion that an accident service

(in a coal field) must be related geographically to the source of accidents i.e the pits. Many difficulties will require to be overcome before such a scheme will mature, but a regional hospital authority may help.

It is immaterial whether such a service is housed in an existing hospital, or in a Special Accident Hospital. The point is, that, to do justice to the work, the department must be self-contained and adequately staffed.

The first requisite is beds. The bed - population ratio should be about 8 to 1,000 miners, so that a hospital of 120 - 130 beds would serve a mining population of 15,000. This high ratio is necessary because of (1) the high accident rate and (2) the necessity to admit patients with hand injuries. The staffing of such a unit must be generous, as the work is incessant and arduous. It is considered that, for such a unit, there should be the following medical staff :-

(1) A Senior Surgeon,

(2) An Assistant Surgeon,

(3) A Resident Surgical Officer,

(4) A Ward House Surgeon,

(5) An Out-Patient House Surgeon,

(6) A Resident Anaesthetist,

(7) A Visiting Radiologist.

The unit should possess its own X-ray Department, with a Radiographer in charge. Both House Surgeons and the Resident Surgical Officer should be capable of taking a straightforward x-ray e.g. femur, tibia, humerus, forearm etc.,

and with modern mobile units the technical knowledge required is minimal.   The mobile unit must be capable of taking first class radiographs, and should have an output of at least 60 kVP at 30 mA.   The unit must be readily moved, the tubehead must be readily adjustable and the whole electrically safe.

The actual X-ray Dept. must be the focal point of the service, and must be located on the same floor as the wards, theatre etc.

A Physiotherapy Dept. is essential.   Such a department would require a Charge Physiotherapist and three assistants. The writer strongly favours women physiotherapists in preference to men: there would appear to be little doubt that male patients respond exceptionally well to the ladies! The motto of the department must be "active movement" and passive physiotherapy must take a second place.   Remedial exercises in all forms is the basic treatment.   Faradic and Galvanic stimulation of muscle etc. may be necessary in some cases.   Diathermy is of value in selected cases, e.g. contusion of osteo-arthritic joints etc., but its place is not great.   Aerated baths are thought highly of by some, but the writer feels that these virtues are exaggerated. Massage, in its various forms, is of great value at times, but it must be prescribed by the Surgeon for specific cases only.

The gymnasium is important.   All forms of apparatus are useful - wall-bars, nautical wheel, rowing exercises, stationary bicycles etc. - but it must be appreciated by the

staff that such devices are merely to be used as stepping stones to hard rehabilitation.

Rehabilitation facilities are now available for practically all coal-fields, but it must be clearly recognised that such centres can only take about 50 patients at one time, and these centres do not therefore excuse any accident service from providing rehabilitation treatment for the many cases who do not require resident rehabilitation treatment. Miller (Ref. 1) has shown what can be done with simple out-patient rehabilitation.

The Surgeon must prescribe the type of treatment, and the charge physiotherapist can work out the details e.g. a prescription for treatment of a meniscectomy case four days after operation would be :-

(1) Faradism, if necessary,

(2) Quadriceps Drill,

(3) General R.E.

This might be interpreted as :-

(1) Faradism - not necessary,

(2) Active contraction of quadriceps with straight leg, graduating to contraction with the knee flexed,

(3) General R.E.,

    (a) Breathing R.E.,

    (b) Arm and Shoulder exercises,

    (c) General R.E. for sound leg.

The physiotherapist must realize, as must the nursing staff, that her ward work is of great importance.

Simple rehabilitation can be carried out in a wooden

shed in inclement weather, but whenever possible games, cycling, exercises etc. should take place in the fresh air. Elaborate occupational therapy (weaving etc.) can be left to the main centres, but it is a simple matter to arrange carpentry, basket work, netting etc.

An Out-Patient Department must be provided on a generous scale, and should comprise two sections, (1) Out-Patient Fracture Clinic and (2)Casualty Clinic.   There is much to be said in favour of these departments being adjacent.

(1) The Fracture Clinic must have the following accommodation :-

(a) Waiting Room,

(b) Examination Room,

(c) Plaster Theatre,

(d) Records Office.

(2) The Casualty Clinic requires :-

(a) Waiting Room,

(b) Reception and Examination Room,

(c) A simple Operating Theatre for clean cases,

(d) A simple Operating Theatre for septic cases,

(e) Two Dressing Rooms - one for clean cases, one for septics.

(f) A small Casualty Ward with 4 - 6 beds,

(g) A Recovery Room.

With such a unit, one can visualize an accident service of great efficiency, and the experience gained by the surgical staff would be immense.   As a result, one could look for steady improvement in results, and the study

of certain types of trauma would be of great value.

Possibly such a scheme is imaginary as yet, yet the author has discussed this subject with influential men in the Coal Trade and has found an appreciative audience.

Stewart, (Ref. 63) discussing the implications of the new National Insurance (Industrial Injuries) Bill, 1945, states -

"For the purposes of the Act, "Medical treatment" means "Medical, surgical and rehabilitation treatment, including "course of diet or other regimen". The Bill goes on to use "the phrases "approved hospital treatment" and medical "treatment given "with the approval of the Minister". "Regulations may also provide for determining "in what cases" "and "for what periods" treatment is to be carried out. Is "there therefore to be some selective method of treatment? " Are some hospitals not to be approved? Who, on behalf of "the Ministry, will advise approval or disapproval? Will "hospitals with inadequate facilities for accident treatment "remain outside the scheme? Will the Industrial Injuries "Fund itself contribute to the treatment of patients? The "time is now opportune for a scheme to be prepared in detail "for an accident service for the country, and for a more "critical survey of the accident treatment facilities in "different areas than those already carried out".

Such an opinion will be supported by many surgeons who have to deal with accident surgery, and there is no doubt that the opportunity of reorganisation presented by the introduction of a national health service should be grasped eagerly. Though the writer has discussed the problem as

it affects a coal-field, the presence of other industries
does not in any way invalidate the suggestions.   In
Lanarkshire (Coal, Steel and Engineering), Staffordshire
(Coal and Potteries), etc., etc., the accident service would
serve all industry, but obviously a careful preliminary
survey would be necessary before deciding the location,
size etc. of accident units.

Bohler performed a great service in awakening British
surgeons to the problem of fracture treatment, and much good
work has been done in the last fifteen years.   Let the good
work on fractures be rounded off to include other accidents
and surely Traumatic Surgery will find an honoured place in
the future of our Hospital Service.

Conclusions.

(1) A review of the accidents met with in coal mines is presented.

(2) The medical profession can help the coal-trade in its present difficulties by arranging efficient treatment for the multitude of colliery accidents, thus cutting to a minimum the loss of man-power through disability.

(3) The problem of a nation-wide organisation of accident treatment has yet to be tackled. The arrangement of an accident service for such an industry as the coal-trade is a matter of national importance. It is unfortunate, in many ways, that Rehabilitation Centres were established in the various coal-fields before the question of primary accident treatment was gone into. The most important incident in the treatment of an accident case is the immediate surgical treatment i.e. rehabilitation commences as soon as the patient is brought to hospital. This fact is not clearly understood by many lay people, who imagine that a badly treated injury with associated stiffness and atrophy of muscles, can be cured in the atmosphere of magic of a rehabilitation centre. It is the duty of the medical profession to preach the true gospel of the continuity of treatment of accidents.

(4) The author claims that decentralization is necessary in arranging an accident service. It may be necessary in places to build new accident hospitals: in other places, a new self- contained department in an existing

hospital would be necessary.

(5) Such units would require generous staffing, as the work is arduous and incessant.

It is suggested that the ratio of beds to population at risk should be (for miners at least) 8 : 1,000. Such a provision would allow of the admission of many finger and hand injuries, at present relegated to out-patient departments, for careful treatment and nursing. In a miner a severely crushed hand is a more serious injury than a fractured humerus.

(6) In such a service, opportunity would exist for research into the problems of (a) fractures of the spine, (b) stiffness of the knee joint following fractures of the femur, (c) finger injuries and finger rehabilitation etc., etc.

References.

1. Miller, A., British Medical Journal, 1942, 2, 209.

2. Bauer, E., "Changes in the Knee Joint at Various Ages", Commonwealth Fund, New York, 1942.

3. Nichol, E.A., British Medical Journal, 1941, 1, 501.

4. Watson-Jones, R., Lancet, 1943, 1, 172.

5. "Final Report of Inter-departmental Committee" Home Office, Scottish Office, H. M. Stationery Office, 1939.

6. Dr. Fisher, "Personal Communication".

7. Vernon, J., The Medical Press and Circular, 1941, 5332, 49.

8. Patrick, W., British Medical Journal, 1944, 2, 788.

9. Ogilvie, W.H., British Medical Journal, 1945, 1, 619.

10. Bywaters, E.G., British Medical Journal, 1941, 2, 29.

11. Watson-Jones, R., "Fractures and Joint Injuries", 3rd Edition E. & S. Livingstone, Edinburgh, 1944.

12. Lancet, 1945, 14, 436.

13. Crisp, J., Lancet, 1945, 14, 422.

14. Burns & Young, Lancet, 1945, 14, 424.

15. Steindler, A., Journal Amer. Medical Ass., 1938, 110, 106.

16. Bankart, A.S.B., Manipulative Surgery, London, 1932.

17. Stirling, R.I., Edinburgh Medical Journal, March 1943, 164.

18. Dandy, W.E., Journal American Medical Association, 1942, 120, 605.

19. Love, J.G., Proceedings Royal Society of Medicine, 1939, 32, 1697.

20. Gillies, H., Kilner, T.P., & Stone, D., British Journal of Surgery, 1927, 14, 651.

21. Ungley, H.G. & Sugget, S.C., British Journal of Surgery, 1944, 32, 287.

22. Neviesir, J.S., J. Bone & Joint Surgery, 1945, 27, 211.

23. Jones, R., "Injuries to Joints", Oxford Medical Publications, 1924.

24. Handfield-Jones, R.M., "Surgery of the Hand", Edinburgh, E.S. Livingstone, 1942.

25. Bunnel, S., "Surgery of the Hand", London, J.B. Lippincott & Co., 1945.

26. Brown, D.O., British Journal of Surgery, 1943, 30, 307.

27. Cuthbert J.B., British Journal of Surgery, 1945, 33, 66.

28. Miles & Wilkie, "Operative Surgery", Oxford Univ. Press, 1933.

29. Bohler, L., "Treatment of Fractures", 4th Oxford Edition, Translated by E.W. Hey Groves.

30. Farquharson, E.L., J. Bone & Joint Surgery, 1946, 28, 1922.

31. Brittain, H., "Architectural Principles in Arthrodesis", Edinburgh, E.S. Livingstone, 1942.

32. Platt, H., Lancet, 1940, 2, 612.

33. Highet, W.B. & Holmes, W., British Journal of Surgery, 1943, 30, 212.

34. Hey Groves, E.W., British Journal of Surgery, 1919, 7, 505.

35. McMurray, T.B., "Robert Jones Birthday Volume", Oxford Medical Publications, 1928.

36. Mercer, W., "Orthopaedic Surgery", London, E. Arnold, 3rd Edition, 1943.

37. Ollerenshaw, J., British Journal of Surgery, 1921, 8, 409.

38. Terhune, S.R., Eddleman, T.S., Thompson, S.B. & Reed, B.S., J. Bone & Joint Surgery, 1943, 25, 663.

39. Cleveland, M., Willier, L.J. & Doran, P.C., J. Bone & Joint Surgery, 1944, 26, 329.

40. Adamson, W.A.D., Edinburgh Medical Journal, 1946, 53, 37.

41. Massert & Naquet, "Bull.et Mem. Soc. d. Chir. de Paris" 1936, 28, 439.

42. Blount, W.P., J. Bone & Joint Surgery, 1943, 25, 319.

43. Moore, A.T., J. Bone & Joint Surgery, 1944, 26, 52.

44. Taylor, S.M., Neufeld, A.J. & Janzen, J., J. Bone & Joint Surgery, 1944, 26, 707.

45. Anderson Roger, "Surg., Gyn., Obst.", 1932, 54, 207.

46. Gissane, W., British Medical Journal, 1939, 2, 985.

47. Bothe & Davenport, "Surg., Gyn., Obst.", 1940, 81, 598; 1942, 84, 231.

48. Dick, I.L., J. Bone & Joint Surgery, 1946, 28, 1.

49. Higgs, L.S., J. Bone & Joint Surgery, 1946, 28, 15.

50. Campbell,   Lancet, 1938, 2, 872.

51. Ashhurst & Bromer, Arch. of Surgery, 1922, 4, 51.

52. Watson-Jones, R., British Journal of Surgery, 1938, 25, 773.

53. Leimbacker, E.S., J. Bone & Joint Surgery, 1943, 25, 828.

54. Silverstone, M., British Journal of Surgery, 1942, 30, 70.

55. Diggle, quoted by Watson-Jones in "Fractures & Joint Injuries".

56. Irwin, C.G., "Personal Communication".

57. Levine, M.A., J. Bone & Joint Surgery, 1943, 25, 902.

58. Davis, A.G., J. Bone & Joint Surgery, 1929, 11, 133.

59. Munro, A.H.G. & Irwin, C.G., British Journal of Surgery, 1938, 25, 621.

60. Bailey, Hamilton, "Emergency Surgery", Bristol, John Wright & Sons, 1944.

61. Whyte, A.H., "Personal Communication".

62. The National Health Service Act, 1946.

63. Stewart, D., British Medical Journal, 1946, 1, 561.

The following books have been freely consulted :-

1. Manual of Surgery, Miles & Wilkie, Oxford Medical
        Publications,1933.

2. A Short Textbook of Surgery, C.F.W. Illingworth, 3rd Edition,
        London, Cassel & Co., 1944.

3. Textbook of Surgical Treatment, C.F.W. Illingworth,
        Edinburgh, E.& S. Livingstone, 1943.

4. Fractures & Joint Injuries, R. Watson Jones, Edinburgh,
        E. & S. Livingstone, 1944.

5. A Textbook of Operative Orthopaedics, A Steindler,
        New York, D. Appleton & Co., 1925.

6. Orthopaedic Surgery, W. Mercer, London, E. Arnold,
        3rd Edition, 1943.

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