Mice which had Breathed Oxygen at 13 per cent. Pressure.—There were thirty dead mice of all ages which had breathed the lowest pressure of oxygen tested—namely, 13 per cent. Seven, or 23.3 per cent., of them revealed primary lung tumours (Table XI). This is double the control figure of 11.3 per cent. (Table V) for all ages. If we take only the thirteen dead mice older than 10 months which had breathed 13 per cent. of oxygen we find that five, or 38.4 per cent., possessed lung tumours (Table XII) compared with 16.3 per cent. of the controls (Table IX). This is further evidence in favour of anoxia increasing the incidence.

TABLE XI.—Incidence of Primary Lung Tumours in Mice of All Ages Breathing O₂ at 13 per cent. Atmosphere

Mice	No. of Mice	No. of Mice with Lung Tumours	
		Simple	Malignant
1st generation	4	1	0
2nd „	17	2	3
3rd „	9	0	1
Totals	30	3 (7=23.3%)	4

TABLE XII.—Incidence of Primary Lung Tumours in Mice over 10 Months of Age Breathing O₂ at 13 per cent. Atmosphere

Mice	No. of Mice	No. of Mice with Lung Tumours	
		Simple	Malignant
1st generation	4	1	0
2nd „	6	1	2
3rd „	3	0	1
Totals	13	2 (5=38.4%)	3

Tumours of Other Organs

There were no mammary tumours among the mice in the control chamber; but in the low-oxygen-pressure chamber one of the mice (first generation, aged 465 days) had a typical mammary carcinoma with metastases in the lung, and another mouse (original, aged 636 days) had a small mammary tumour. One of the control mice (second generation, aged 455 days) had a carcinoma involving the liver and mesentery, while one of the experimental mice had a fibroma of the subcutaneous tissue near an ulcer. In both groups of mice there were four with some hypertrophy of the mediastinal lymph tissue.

Summary and Conclusion

Heredity (see Campbell, 1937) may play an important part in the incidence of lung tumours in mice. However, we have no reason to believe that heredity has influenced the results for our experimental mice to any greater degree than the results for our control mice. In both cases the mice were from the same stock. Many of the mice considered in the tables were descended from one female mouse—namely, No. 52. Her parents, however, did not possess tumours of the lung.

The results, of course, are rather few in number, but, so far as they go, they indicate that anoxia increases the incidence of primary lung tumours in mice older than 10 months, and may therefore be a factor in the origination of tumour cells.

The results also prove that it is possible to acclimatize mice to 13 per cent. of oxygen—equivalent to an altitude

of about 15,000 feet—so that they breed and rear young which grow at a normal rate under this low oxygen pressure. Previous experiments indicate that 10 per cent. of oxygen, corresponding to an altitude of 20,000 feet, is beyond the limit for full acclimatization for mice and other mammals tested (Campbell, 1935); this apparently holds also for man (McFarland, 1937; Keys, 1938).

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REFERENCES

- Campbell, J. Argyll (1927). *J. Physiol.*, **62**, 211.
 — (1932). *J. Path. Bact.*, **35**, 379.
 — (1933). *Ibid.*, **36**, 243.
 — (1934). *Quart. J. exp. Physiol.*, **24**, 271.
 — (1935). *Brit. J. exp. Pathol.*, **16**, 39.
 — (1937). *J. Indust. Hyg.*, **19**, 449.
 — and Cramer, W. (1928). *Lancet*, **1**, 828.
 Keys, A. (1938). *Ergebn. inn. Med. Kinderheilk.*, **54**, 585.
 McFarland, R. A. (1937). *J. comp. Psychol.*, **24**, 189.
 Wartburg, D., Wind, F., and Negelein, E. (1926). *Klin. Wschr.*, **5**, 829.

WOUNDS PENETRATING THE KNEE-JOINT

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The object of this paper is to record our experience of the treatment of wounds due to penetration of the knee-joint by rock occurring in natives employed in gold-mining operations in South Africa. The conditions are not exactly comparable to those met with on the European battlefields (Frankau, 1939), as the wounds, though they are always contaminated, seldom develop tetanus or gas gangrene. "Penetration of the knee-joint" includes injuries of the large suprapatellar bursa, which is involved in the majority of these accidents.

The condition is of such frequent occurrence that for the past few years the mines have each adopted some form of preventive—for example, various types of knee-guards, of hard or soft crêpe rubber, sometimes combined with a shin-guard resembling a cricket pad. This provision has reduced the incidence of penetrating wounds considerably; but rolling or falling rocks, together with neglect in wearing the guards provided or their improper application, still cause a large number of cases. Knee-guards were introduced to the mine under consideration in December, 1936.

Treatment

First Aid.—It must be insisted that all wounds in the neighbourhood of the knee, no matter how small, be immediately covered with a large sterile dressing and the limb splinted. The patient must then be placed on a stretcher and taken to hospital. Prevention of the use of the limb after injury lessens the blood effusion into the joint and increases the chances of a perfect result.

Diagnosis.—The diagnosis of a penetrating wound is made when synovial fluid is found escaping or is being forced out through the wound on fully flexing the injured knee, which is done by the nursing staff. The patient is then prepared for immediate operation.

Pre-operative Measures.—The wound is covered with an acriflavine dressing and the rest of the limb, from toe

to upper thigh, is scrubbed with soap, shaved, cleansed with methylated spirit, and finally sprayed with a solution similar to that recommended by Tinker and Sutton, but containing only 1 per cent. acriflavine. The whole limb is then enclosed in a thin sterile towel. Spinal anaesthesia is the method of choice, 10 per cent. procaine having been used successfully in nearly all these cases. The following technique is adopted. With the patient sitting up a 2 per cent. novocain solution is injected as a 2½-inch Record needle advances until it enters the spinal sheath between the third and fourth lumbar vertebrae. The needle is either left in place just before tapping the fluid or is withdrawn slightly while the syringe is rinsed and filled with the procaine solution. Before injecting this some of the spinal fluid is withdrawn. It is usually only necessary to employ about 1.5 c.cm. of the procaine solution. A spinal anaesthetic allows the use of a tourniquet without discomfort to the patient. Ephedrine, 1/2 grain, is given to counteract the fall in blood pressure, and the patient is laid flat with his head on a pillow. A bloodless field is achieved by winding a Martin's rubber bandage from the toes to above the knee, the thin sterile towel not being removed. At its upper limit a rubber tourniquet is applied; the Martin's bandage is then removed.

Operative Technique.—After the application of sterile towels a wide excision of the skin wound is made, allowing one-quarter to half an inch margin. Damaged tissues and the edges of the wound are excised down to the capsule, the edges of which are also excised, "non-touch technique" being used throughout. The knee is then alternately flexed and extended by an assistant to extrude all blood clots and fluid. If the joint space is grossly contaminated it is irrigated with pure ether. With fresh instruments the capsule (also the synovial membrane) is now closed with continuous catgut as fine as the situation will permit, thus rendering it "watertight" (Hart, 1939). The skin is secured with interrupted sutures of silkworm-gut without drainage and the wound is well covered with dressings. Before removal of the tourniquet an elastic adhesive strapping, such as elastoplast, is wound from the toes to above the knee to maintain pressure (Lloyd, 1937) without resulting in swelling lower down. No splint is applied unless the infrapatellar tendon is severed. The limb is left thus for ten days, the patient being kept strictly in bed. The elastoplast and stitches are then removed and exercise is allowed, the amount depending on the strength of the granulations and severity of the wound.

Results

Following this routine with only slight modifications, the results tabulated below were obtained during the past four years. Our records cover 151 cases.

TABLE I.—Showing the Average Period of Incapacitation

Yearly Period	No Final Disability	Cases with Some Disability		
	Av. Days in Hosp.	Av. Days in Hosp.	Av. Total Days Incap.	Av. % Disab.
Oct., 1935, to Sept., 1936 ..	18	25	30	5
" 1936, .. 1937 ..	14	28	45	6.6
" 1937, .. 1938 ..	14	21	38	6.3
" 1938, .. 1939 ..	15	22	45	3.7
Total for 4 years ..	15	24	39	5.4

Patients with no final disability were discharged from hospital in an average of fifteen days. They were usually

employed on light work for a further average of seven days before being returned to their own occupation. These with some disability were also employed on light work after leaving hospital; but this period was usually longer, bringing the length of incapacitation up to an average of thirty-nine days, twenty-four of which were spent in hospital. Damage to cartilaginous or bony structures of the joint at the time of the injury is responsible for a proportion of the permanent partial disability. This disability, assessed at an average of 5.4 per cent. over the four years, had in most cases entirely disappeared when the natives completed their period of employment on the mine. The average lapse of time between resuming normal work and leaving employment was four and a half months in all natives, with or without disability.

TABLE II.—Showing Results of Treatment

Yearly Period	Returned to Work			Repatriated	Total Cases
	No Disab.	Some Disab.	Total		
Oct., 1935, to Sept., 1936	5 (15%)	22 (65%)	27 (80%)	7 (20%)	34
" 1936, .. 1937	15 (48%)	12 (39%)	27 (88%)	4 (12%)	31
" 1937, .. 1938	24 (65%)	8 (22%)	32 (87%)	5 (13%)	37
" 1938, .. 1939	19 (39%)	26 (53%)	45 (92%)	4 (8%)	49
Total for 4 years	63 (41%)	68 (46%)	131 (87%)	20 (13%)	151

A fall is shown in the number returned to work with no disability in the last year, but this is offset by the slightness of the disability and the total number (92 per cent.) returned to work. Thirteen per cent. of the patients were repatriated owing to the disability sustained—for example, arthritis or ankylosis—preventing further employment on the mine.

Summary

A method of dealing with wounds penetrating the knee-joint is described, with particular emphasis on first-aid treatment, pre-operative preparation, and operation under a spinal anaesthetic.

These cases must be treated as surgical emergencies, and attention to detail is emphasized.

The capsule and skin of all knee-joint wounds are sutured after complete excision of damaged tissues, without drainage.

The use of Martin's rubber bandage before and elastoplast bandage after the operation is advocated.

Results of treatment of 151 cases in four years are given.

REFERENCES

- Frankau, C. (1939). *British Medical Journal*, 1, 989.
Hart, A. T. (1939). *Ibid.*, 1, 1099.
Lloyd, E. I. (1937). *Ibid.*, 1, 1015.

The Department of Scientific and Industrial Research has issued a further leaflet in the series "Methods for the Detection of Toxic Gases in Industry" dealing with carbon monoxide (Leaflet No. 7, H.M. Stationery Office, 1s. 6d.). Among the industrial situations in which this gas may be encountered in dangerous concentrations are blast furnaces, brick kilns, chemical works, foundries, gas works, coke ovens, and lime kilns. Carbon monoxide is colourless and odourless and is, therefore, most insidious in its action. The first symptoms of poisoning are shortness of breath and palpitation on exertion, accompanied by headache which increases in severity. With increasing intoxication the judgment becomes disturbed and the affected person may not realize his danger. An atmosphere in which a concentration as low as 1 part in 2,000 is present may prove fatal in about one hour to a person engaged in an active occupation. On the other hand, concentrations below 1 in 10,000 may be regarded as relatively harmless for all practical purposes.