

HAND INJURIES CAUSED BY OIL INJECTION UNDER PRESSURE

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In 1937 Rees described what appears to be the first case reported of an injury resulting from the penetration of tissue by oil. This report concerns a motor mechanic who was testing the jet of a diesel engine and was holding the jet, which he had removed from a cylinder head, about 1 in. from the tip of his right middle finger when he tripped the valve. Oil was forced from the jet into the finger at a pressure which he estimated to be about 4,000 lb./sq.in. There was immediate slight bleeding from several points in the finger tip and pain which gradually became intense. When the patient was first seen 24 hours later, opiates were necessary to relieve the pain. At this stage the finger and hand were oedematous, swollen and tense. The pain in the finger persisted but the pain and swelling in the remainder of the hand subsided. Subsequently gangrene resulted, which began at the tip of the finger and extended down to the first interphalangeal joint.

An exploratory incision over the first phalanx at this time showed that all the tissue in this area had undergone liquifaction necrosis with secondary infection. A thick creamy pus was present. Bleeding was very slight. The tissue at the base of the finger later developed the same dusky red colour which was noted previously in the finger before it became gangrenous.

Amputation was then performed through the middle third of the metacarpal bone. The swelling and pain in the remainder of the hand subsided immediately. There was considerable suppuration in the area of amputation following operation, and it was not until 8 weeks later that healing was complete.

Since Rees' original report many further accounts have been published of hand injuries sustained by mechanics who work with high-pressure diesel lubrication. The clinical picture remained one of swelling and severe pain lead-

ing later to necrosis. Early incision and release of the oil often prevented gangrene.

Injuries Caused by Diesel Fuel under Pressure

In diesel engines the diesel oil is forced through an injector into the combustion chamber under very high pressure. A heavy, less refined, oil is used in marine engines, but a light oil, of low viscosity and highly volatile, is used in automotive engines such as tractors. A jet of this oil, under a pressure of 2,000 - 6,000 lb./sq.in., with the muzzle velocity of a rifle, is capable of severe damage to tissue when contact or near contact to the nozzle is provided.

Injuries from diesel oils are commonly caused through careless handling of diesel injectors. The injection system comprises the commonest form of fuel supply of diesel engines and is of great potential danger to those workers who are concerned with their repair.

Fig. 1 shows the injector unit of a diesel gun being tested in a workshop in Cape Town. Note that the nozzle has 4 small holes drilled at a pre-determined angle through which the diesel oil is injected under pressure to the cylinder head.

The small bore of these holes in the injector nozzle provides fragmentation or volatilization of the fuel. The cylinder head as recipient is thus supplied with a 'cloud' of diesel fuel. The velocity of fuel ejected from the nozzle varies according to the size of piston and the type of engine, but 50 ft./sec. is an average for two-stroke engines.

The injector demonstrated in Fig. 1 operates at a delivery pressure of 2,000 lb./sq.in. as indicated on the gauge and the volatile fuel can be clearly seen radiating like the spokes of a cartwheel. This velocity, plus volatilization and pressure head, explains the ease with which such oil

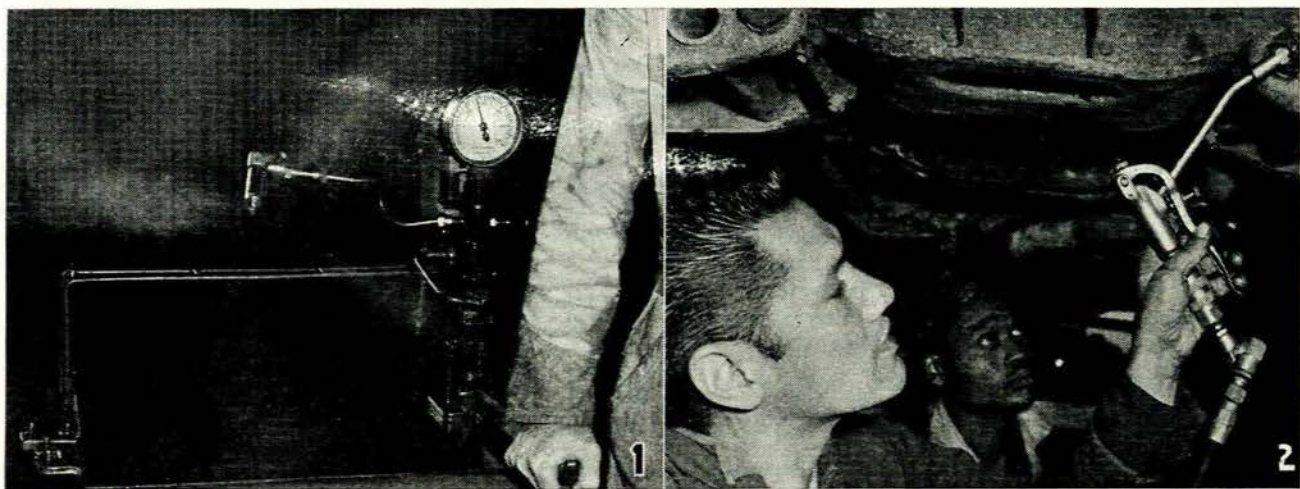


Fig. 1. Injector unit of a diesel engine being tested. Note the four clouds of volatile fuel ejected from the nozzle.
Fig. 2. Garage mechanic using grease-gun operated by air pressure.

may be injected into human tissues, even without showing an entrance wound.

The diesel fuel may enter into the tissues either in its intact jet form or while in the volatile phase. This may occur inches away from the nozzle itself. These injuries may occur during the overhaul of a diesel engine or when the injector mechanism itself is tested.

'Grease-gun' Injuries

Subsequent to Rees' original article on diesel oil injuries in 1937, Hilton H. Smith in 1939 reported a case of destruction of a finger by grease injected into the pulp of the finger by a mechanic who was lubricating the springs of a passenger car with a device which ejects grease from a hollow needle inserted into the grease fittings. His right hand, which held the 'gun', slipped and the needle barely touched the skin at the volar base of the index finger. The valve automatically tripped and the grease was forced into his finger. Here again there was the story of swelling and intense pain of the finger followed later by gangrene. Numerous accounts have subsequently appeared on this so-called 'grease-gun finger'.

High viscosity oils are used in grease-guns similar to the one demonstrated in Fig. 2 for lubricating purposes in food machinery, car blades and transmission cables. The old hand-type of lubricator is no longer used and most garages utilize a grease-gun which is operated by air pressure. The working pressure is usually only 30 - 150 lb./sq.in., but when the nozzle gets blocked, tremendous pressure may develop. Sudden dislodgement under high pressure may propel the grease or oil with great velocity causing injuries similar to those which are seen with high-pressure diesel injectors. Byrne mentions a case where injury to a hand occurred at a distance 8 inches away from the grease gun.

THE CLINICAL PICTURE

When oil is accidentally injected into a hand the clinical picture is as follows.

1. *The Acute Phase*

The entry of the oil causes an instantaneous swelling of the affected finger or the hand. The patient may notice that the finger has suddenly become three or four times its normal size. Initially it feels numb but within half-an-hour it becomes extremely painful. There may be a small puncture wound where the oil entered the finger or there may be no mark at all. If there is a puncture wound it is sometimes possible to express a drop of grease.

In the acute phase the pain and swelling is due to the pressure of the injected oil in the closed space of the finger or hand. This increase of interstitial pressure may traumatize the tissue beyond repair. The mass of injected material may cause total obliteration of arterial pressure so that local necrosis or gangrene of the whole distal finger may follow, pending the duration of such vascular occlusion.

2. *Secondary Phase*

If the original pressure does not cause irreparable damage and gangrene, the oil may set up a chemical reaction with local inflammation and sterile abscesses. This further destroys the affected area. Some authors have described multiple subcutaneous abscesses which may discharge through the skin leaving small pits in the skin through which the grease is extruded.

The type of diesel oil probably plays a significant role in this phase. The lubricating oils used in grease-guns possess large quantities of impurities such as carbon, sulphur, vanadium and other volatile ingredients. These substances are the chronic irritants which cause the subsequent fibrosis and sinus formation.

If a secondary infection supervenes there will be all the obvious sequelae.

3. *Chronic Phase*

If the finger is not lost through gangrene the local inflammation set up by the oil persists. The oil may be extruded through chronic sinuses or may be encapsulated in the form of small globules in chronic inflammatory tissue and remain permanently in the injured area. In many cases this inflammation persists over many months and even years and causes serious inconvenience to the worker and loss of working time.

The encapsulated oil, which is not inert, may result in the formation of a 'tumour' which consists of cystic areas, filled with oil, surrounded by dense fibrous tissue.

A patient seen by the authors presented with such an oleoma, 9 months after the original injury. This patient typically demonstrates all 3 clinical phases of an injury due to the injection of oil at high pressure. Histological examination of the tumour tissue excised gives a clear picture of the chronic phase.

CASE REPORT

J.A., a non-White male, aged 19, was referred to the Karl Bremer Hospital by his general practitioner for amputation of his right thumb, 9 months after an injury sustained while attempting to seal off a jet of diesel oil, escaping under high pressure from a tiny hole in the feeding mechanism of a diesel engine.

Immediately following the injury the patient had experienced severe pain in his right thumb, especially on the palmar aspect. He noticed that the circumference of his finger had suddenly increased about three-fold, and that the finger 'had a grey colour'. There was no entrance wound. He was unable to flex the metacarpo-phalangeal joint.

One week later the swelling and pain forced him to pay a visit to his general practitioner who drained a small abscess on the palmar aspect of the thumb and commenced antibiotic therapy. Two further abscesses subsequently required drainage.

When first seen by the authors 9 months later the patient complained of chronic pain and inability to use his right thumb. As a result of this, he had been unemployed since the accident.

On examination there was gross swelling of the right thumb (Fig. 3) with visible scars where previous surgical drainage had been performed. The skin was otherwise smooth.

Movement, especially flexion, was limited to about 10% of normal and only 15° of apposition was possible. All the movements could be initiated suggesting intact nerves and tendons. There was only slight diminution of sensation over the terminal phalanx. The entire thumb on palpation felt rubbery hard in consistency. There were no signs of acute inflammation and no sinus formation.

X-ray examination was negative.

The patient initially refused all conservative measures and insisted on having his thumb amputated so that he could return to work as soon as possible. When informed about the possibility of retaining his thumb if subcutaneous resection of the foreign material was carried out he eventually consented to have this operation done.

Operation

A tourniquet was applied and under bloodless field the thumb was opened through a T-shaped incision which was commenced in the interphalangeal crease and extended over the

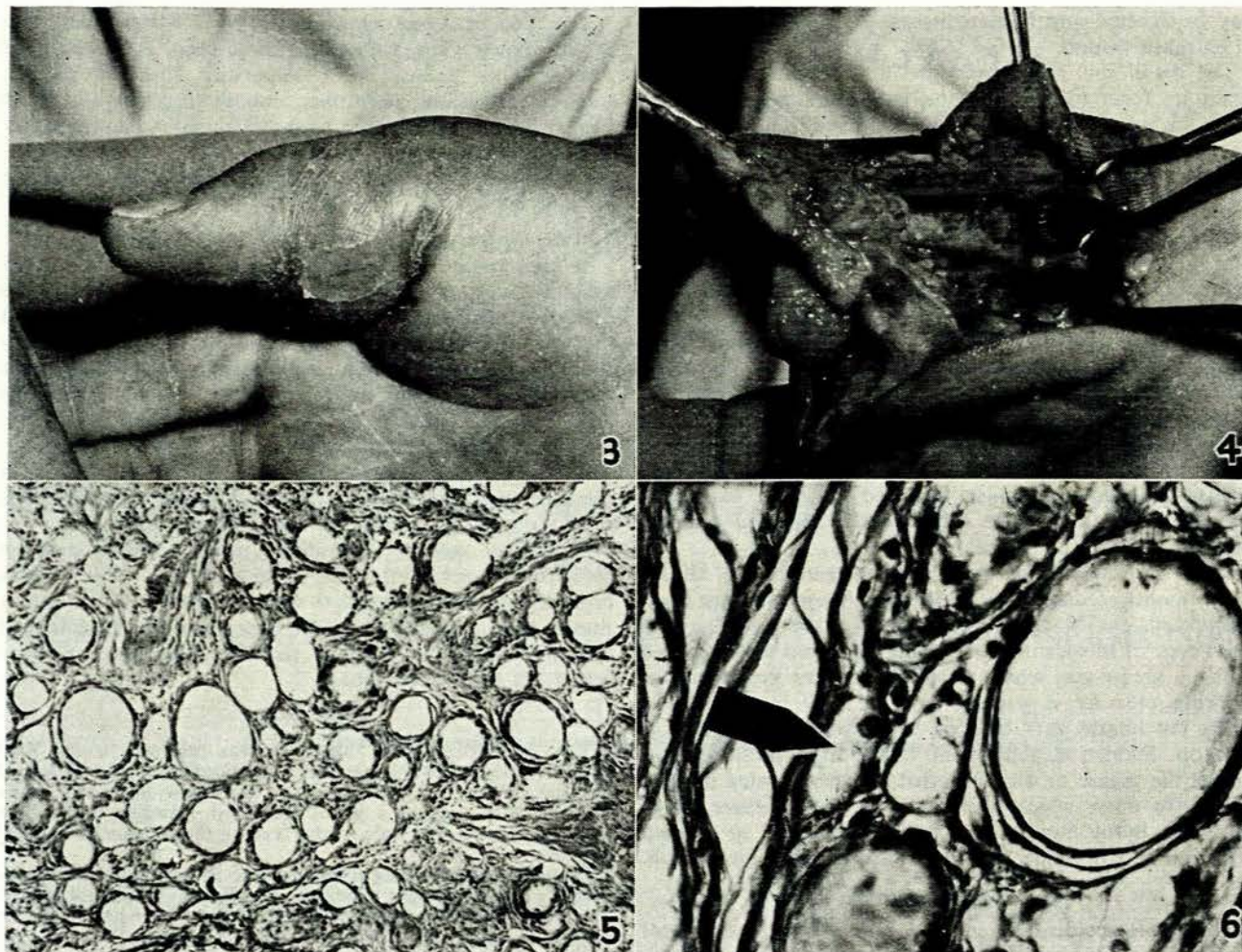


Fig. 3. Grossly swollen right thumb, with visible scars where previous surgical drainage had been performed.

Fig. 4. Digital vessels and nerves and the flexor tendon identified at operation. Abnormal tissue consisting of fibrous tissue and multiple oil globules being removed.

Fig. 5. Histological view showing multiple oil globule spaces with surrounding tissue reaction.

Fig. 6. Higher magnification showing oil globule on the right. The arrow indicates a large histiocyte with foamy cytoplasm and giant cell formation above it.

thenar eminence so as to include the scars of the abscess incisions. Two skin flaps were raised. It was impossible to find a line of cleavage between skin and foreign-body material. As much abnormal tissue as possible was dissected from the skin flaps.

The digital nerves and arteries, intimately involved in the abnormal tissue, were then identified and dissected free as shown in Fig. 4. As much affected tissue as possible was then removed. This consisted of fibrous tissue containing multiple globules of gold-coloured diesel oil.

The skin was sutured in position with fine black silk and a corrugated drain left in position for 48 hours.

Postoperatively there were no complications and 1 month later the patient was back at work with a painless thumb.

When seen 1 year later the patient had no complaints. The thumb still appeared slightly thicker than the other side but the function had returned to normal.

Histological Report on the Tissue Excised

Dr. D. de Villiers, of the Department of Pathology, University of Stellenbosch, supplied the following histological report:

The histological picture shows multiple oil globule spaces and a well-marked foreign-body granulomatous reaction.

There are multiple granulomatous follicles consisting of histiocytes, some of which have a foamy cytoplasm and occasional foreign-body giant cells. The granulomas are surrounded by dense interwoven collagen fibres (Figs. 5 and 6).

TREATMENT OF OIL INJURIES

It is, of course, essential that all garage hands and mechanics who work with diesel fuel injectors or with grease-guns operated under high pressure should be instructed in their correct use. They should be warned that careless handling may result in a serious hand injury.

Once an injury has occurred the oil should be released as soon as possible. Early adequate incision is indicated. Release of the interstitial pressure allows the blood to circulate again and prevents further tissue damage. The incision should be done under general anaesthesia so as not to jeopardize the blood supply any further by the injection of local anaesthetics. The incision is made at the site of the puncture wounds or, if these are not present, at the site of maximum swelling. As much of the oil as possible

is expressed. It may be of use, as Arnold suggests, to wind a soft catheter around the finger starting proximally and working towards the fingertip to force out the oil.

The hand should then be elevated and the patient put on antibiotics.

Many authorities have stressed that the final outcome of their patients might have been more satisfactory if more radical surgery had been carried out earlier. The deceptive paucity of the symptoms at the onset often persuaded against this. It is important to stress the point that although the initial injury appears trivial the actual degree of tissue involvement may be great.

The injury must be considered a serious one since in a large percentage of the cases described in the literature, the patients either lost a finger or were unable to perform their normal duties for many months because of a chronically swollen and painful finger. This is demonstrated by our patient.

When subcutaneous oleomas develop they should be excised. Their removal is best performed under general anaesthesia and in a bloodless field. A careful dissection

should be done so as to remove as much of the abnormal tissue as possible.

SUMMARY

A review is given of the literature on hand injuries caused by the penetration of oil under high pressure. The mechanism of these injuries is explained and the effects of injected oil on the tissues described. A case is reported of a patient who sustained such an injury and 9 months later presented with an oleoma in the thumb. It is stressed that the long inactivity caused by this apparently trivial injury can be prevented by proper initial treatment.

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