Hyperbaric oxygen used in the treatment of gas gangrene in a dog

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ABSTRACT

Gas gangrene developed in the hindlimb of a dog after open reduction and stabilization of a compound femoral fracture. The condition occurred despite prophylactic ampicillin treatment and failed to respond to local irrigation and intravenous penicillin therapy. Three sessions of hyperbaric oxygenation were given. Used in combination with surgical drainage and high doses of intravenous penicillin, an excellent recovery was achieved.

INTRODUCTION

Gas gangrene is an acute myonecrotic disease caused by clostridial organisms (Slack, Hanson & Chew, 1969). Although experimental evidence (Mason, 1942) shows that dogs can be infected, to date only sixteen clinical cases have been described. Both Denny, Minter & Osborne (1974) and James & Goldfinch (1974) have described cases, reviewed the literature and detailed treatments. They noted Clostridium welchii was isolated from all cases where the organism was positively identified. Successful treatment of the condition has included the use of antibiotics in combination with antiserum (Linzell, 1944), oxygen infiltration (Cautley & Baldwin, 1946) and surgical debridement and drainage with local flushing of soluble penicillin (Denny et al., 1974).

Gas gangrene occurs when an inoculum of the causative organism proliferates in an ischaemic focus. Liberation of calcium salts from a fracture site causes a lowering of the oxidation–reduction potential and concurrent growth of aerobic organisms further deplete the oxygen contained in the tissue environment (Robbins, 1967). A compound fracture has a combination of compromised blood
supply, bacterial contamination and calcium salt liberation, predisposing the area to gas gangrene formation. In human civilian medicine, motor vehicle accident trauma is responsible for the major portion of cases, most of which occur in the lower limbs (Unsworth, 1973).

Management of human cases of gas gangrene differs from that described previously for the dog and consists of an aggressive triple therapy of hyperbaric oxygenation (OHP), high doses of i.v. penicillin, and surgical debridement. Unsworth (1973) states that the use of the triple therapy has increased the survival rate to 75-80% from the 40-60% seen with surgery and antibiotics alone. The purpose of this paper is to describe the successful treatment of gas gangrene with a triple therapy regime of hyperbaric oxygenation, i.v. antibiotics and surgical debridement in a dog.

**CLINICAL HISTORY**

A 4-year-old male Irish Setter dog was admitted to a local veterinary hospital following a motor vehicle accident. On presentation the dog was found to be suffering from shock, abdominal pain, dyspnoea and a hind limb lameness. The referring veterinary surgeon administered i.v. fluids and commenced parenteral antibiotic therapy. Radiographs revealed an oblique fracture of the proximal one-third of the right femur.

On referral to our hospital 3 days after the accident, the dog was again in a state of shock, and unable to stand. The mucous membranes were extremely pale, the pulse weak, respiration shallow and a large swelling was evident over the right femur. The distal part of the right hindleg was cold to the touch. The PCV was 18% and the dog was transfused with 1000 ml whole blood, and 1000 ml of Hartmann’s solution. As the transfusion progressed, the swelling over the fractured femur enlarged markedly.

Subsequent consultation with the referring veterinary surgeon revealed that the dog had been tranquillized with 10 mg acepromazine maleate 2 hours before admission to our hospital and this fact was thought to have contributed to the previous shocked state. The following day the dog was much brighter and walking on three legs. The dog was anaesthetized and the limb prepared for surgery. The soft tissues were severely contused, and the *M. biceps femoris* and *M. vastus lateralis* showed severe bruising. During surgery there was continual oozing of venous blood. The haematoma was cleared from the fracture site, the fracture reduced and stabilized with a 3/8” Steinman intramedullary pin. The alignment was good and the incision closed. After the operation the animal was maintained on oral ampicillin (Penbritin, Beecham) 10 mg/kg, b.i.d.

Immediate post-operative progress was uneventful, but on the fourth post-operative day oedema of the distal extremity of the fractured leg was apparent and swelling at the surgical site had appeared. Check radiographs on the sixth post-operative day, revealed pockets of gas in muscle adjacent to the fracture. A
tentative diagnosis of gas gangrene was made and this was confirmed by the presence of many large Gram positive rods found on smear from the aspirated fluid. Culture was attempted, but due to technical difficulties only aerobic coliforms were isolated.

Therapy of $1 \times 10^6$ i.u. benzyl penicillin was given i.v. every 6 hours and a tubular surgical drain inserted so that the area could be flushed with benzyl penicillin.

On the eighth post-operative day the dog was depressed. The oedema of the lower limb was still present and circumscribed 'erysipelas-like' purple areas had appeared on the skin around the stifle and hock. The temperature had fluctuated between 38.4 and 39.5°C, over the previous 4 days and the animal's condition was deteriorating despite oral and local penicillin therapy.

Due to the failure of conventional therapy it was decided to institute hyperbaric oxygen therapy (OHP) and to increase the penicillin to $5 \times 10^6$ units i.v. morning and night.
OHP therapy began on the eighth post-operative day. The dog was premedicated with 1.2 mg atropine sulphate and 2.5 mg of acepromazine, and anaesthesia was induced with nitrous oxide, oxygen and halothane using a face mask. The dog was intubated, and anaesthesia maintained with spontaneous respiration using oxygen and halothane. The initial therapy was at a pressure equivalent to 66 ft in sea water or 3 atmospheres OHP (3 ATA), but after 20 minutes ventricular premature contractions developed together with muscle twitching. Considering that these effects may have been due to an elevated partial pressure of carbon dioxide in the dog, intermittent positive pressure ventilation (IPPV) was commenced but failed to correct the above abnormalities. The level of OHP was reduced to the equivalent of 50 ft in sea water (2.5 ATA) and this together with IPPV resulted in a normal ECG and no further twitching. The animal was kept at this pressure for 80 minutes before decompression and release from the chamber. Recovery from anaesthesia was uneventful.

On the following day, hour-long morning and afternoon sessions were given, using the same anaesthetic induction technique, at a pressure of 50 ft in sea water (2.5 ATA). Toxic reactions were not seen on these later occasions and after the second session the dog appeared much brighter, so much so in fact that he resented induction for the third and final therapy session. Radiographic examination after the final OHP therapy session showed that gas was no longer present in the tissues.

High-dose benzyl penicillin was given i.v. for 7 days after the diagnosis of gas gangrene and ampicillin therapy was continued during this period. The drain was removed 20 days post-operatively.

On examination 4 months after the surgery, the dog had normal use of the leg, the fracture had healed, and the pin was removed.

DISCUSSION

Healthy ruminants are known to harbour clostridial spores within their tissues and the same is true for dogs (Pope et al., 1945). Cobb & McKay (1962) reported that of the twenty dog livers examined, the majority contained Cl. Chauvoei spores, and that Cl. welchii was only rarely detected. Gas gangrene will occur when clostridial spores are provided with anaerobic conditions. In this case tissue ischaemia from a compromised blood supply, a blood loss anaemia and a hypotensive episode, due to overzealous tranquillization, may all be implicated. The concurrent growth of a coliform in the tissues and the presence of bone fragments provided the necessary conditions for clostridial growth.

In this case the dog failed to respond to the usual veterinary regime of antibiotics, and surgical drainage. Deveridge & Unsworth (1973) described in detail the treatment of human patients where diagnosis is confirmed by the presence of large Gram-positive rods on a smear from the deep tissues combined with the characteristic clinical features. These are toxic state, elevated temperature, limb pain, oedema and swelling, palpable gas, discharge of a serosanguinous
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Fluid and the classical changes of bullae and 'bronze erysipelas'. Once diagnosed, patients are treated as soon as possible in the hyperbaric chamber, breathing oxygen through a mask at 3 ATA and given three 2-hour sessions in the first 24 hours, followed by two similar 2-hour sessions on each of the 2 succeeding days. High doses of antibiotics are given and as there has been virtually no development of resistance to penicillin, which is bactericidal for these organisms, Penicillin G (benzyl penicillin) is the drug of choice. The recommended human dose is 5 megaunits (3 gm) i.v. to commence therapy, and then 2–3 megaunits i.v. every hour, depending on the severity and adequacy of renal function. A broad spectrum antibiotic such as kanamycin or gentamycin is also given. Recommended surgery involves the excision of all necrotic tissue, haematoma, and any foreign material present, following which wide and open drainage is maintained. The wound is encouraged to heal by granulation. Although OHP, i.v. antibiotic therapy and surgical debridement may be possible in the veterinary situation, it was considered that wide and open drainage with healing by granulation could lead to osteomyelitis and was not used in this case.

The historical aspects of hydrobaric oxygenation of experimental animals have been reviewed (Bean, 1945). Convulsive seizures similar to strychnine poisoning are recorded in conscious animals after release from the hyperbaric chamber, even following slow decompression. Oxygen toxicity is clearly a problem in this species and in this light Berezin et al. (1970) state that the time of harmless inhalation of oxygen in (conscious) dogs at 3 ATA is 74±13.6 minutes. Van der Brenk (1968) comments that barbiturates and other anaesthetics will raise the convulsant threshold, although Bean (1931) records convulsions at 3 ATA with dogs anaesthetized with urethane. Menije & Straub (1965) used barbiturate anaesthesia at 3 ATA for 4 hours and reported convulsions only under light anaesthesia, and similarly Vermeulen-Cranch (1963) ventilated dogs at 3 ATA for intrathoracic surgery using an oxygen/halothane mixture without ill effect.

Karasewich et al. (1963) used OHP therapy on conscious animals in the treatment of gas gangrene in the liver of the dog produced by ligation of the hepatic artery. Survival rate was doubled by using twice daily sessions at 3 ATA for 2 hours each compared to either single daily sessions, or none at all. However, many animals did show toxic signs with the repeated hydrobaric sessions.

The rationale for the use of OHP is the inactivation of circulating alpha toxin and the inactivation, or destruction, of the strict anaerobes by providing an aerobic environment within the ischaemic tissues (Deveridge & Unsworth, 1973). The OHP therapy increases the oxygen tension within the blood and hence the amount of oxygen carried in solution. Menije & Straub (1965) recorded from dogs under OHP conditions at 3 ATA during barbiturate anaesthesia a mean arterial oxygen tension of 1600 mmHg compared to a mean of 90 mmHg outside the chamber. Breathing oxygen, at 1 ATA outside the chamber a $P_{O_2}$ of 550 mmHg was recorded, showing that three-fold increases in tension provide good oxygenation of ischaemic tissues where anaerobic clostridia are unable to survive oxygen tensions greater than 90 mmHg (Gottlieb, 1971).
In conclusion, the present authors report that OHP therapy has been used on a clinical case of gas gangrene, together with intravenous penicillin and surgical drainage, to effect a satisfactory resolution of a surgical complication. The use of OHP is encouraged provided the patient is anaesthetized and adequately monitored and observed during treatment.

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REFERENCES

Bean, J.W. (1931) Effects of high oxygen pressure on carbon dioxide transport, on blood and tissue acidity and on oxygen consumption and pulmonary ventilation. J. Physiol. 72, 72.
Menije, N.G. & Straub, J.P. (1965) Oxygen tolerance and biochemical response of anaesthetised dogs during oxygen ventilation at 3 ATA. Proc. 3rd Int. Conf. on Hyperbaric Medicine, 151.