INTRA-ARTERIAL TRANSFUSION IN THE TREATMENT OF SEVERE INJURY

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This paper is a description of a method of intra-arterial blood transfusion using oxygen under pressure. An account is given of its use in three patients in severe shock after multiple injuries. It has also been used in seven patients during operations in which severe loss of blood was possible.

Intra-arterial transfusion of blood was suggested by Halsted (1883) as a treatment of carbon monoxide poisoning. Much of the published experimental work was done in America towards the end of the first half of this century. In experiments on dogs Kohlstaedt and Page (1943) found that intra-arterial transfusion was superior to the intravenous route in the treatment of severe haemorrhage, especially when the volume transfused was less than the volume lost. Porter, Sanders and Lockwood (1948) described a method of intra-arterial transfusion in man using oxygen under pressure. The method described here is an adaptation of that method.

Many other methods using machine and hand pumps have been described (Robertson, Trencher and Dennis 1948; McKenzie and Morton 1951; Seeley, Nelson and Wesolowski 1952; Hamilton, Drye, Kinnaird and McGowan 1952; Brown 1953).

The advantages of intra-arterial transfusion are: 1) a rapid transfusion can be given to
shocked patients with collapsed peripheral vessels; 2) there is much less danger of overloading the pulmonary circulation, especially in the elderly patient; 3) rapid increase in blood pressure and improved tissue perfusion can be obtained; 4) it combats the harmful and sometimes lethal effects of tissue anoxia caused by prolonged hypotension; and 5) a small quantity of blood intra-arterially gives better results than the same volume intravenously (Kohlstaedt and Page 1943).

The disadvantages of this method are: 1) it requires more apparatus and more supervision; 2) it is sometimes necessary to expose and ligate an artery; and 3) severe ischaemic changes may occur in the limb distal to the site of the transfusion.

**Diagram of the apparatus.**

**Indications for intra-arterial transfusion**—The indications for intra-arterial transfusion in surgery are at present: 1) severe shock after injury which is not responding to intravenous transfusion (Robertson et al. 1948); 2) severe blood loss especially in elderly patients—for example, after massive haematemesis when surgical intervention is contemplated; and 3) replacement of blood which has been withdrawn to induce hypotension during a major surgical procedure (Brown 1953).

**TECHNIQUE OF TRANSFUSION**

Using the apparatus shown in Figures 1 to 3, the transfusion is made by forcing blood from a standard blood bank bottle into an artery of the recipient by means of the pressure supplied by a cylinder of oxygen. As shown in Figure 3, the oxygen is led through a reducing valve which reduces the pressure to half an atmosphere, and then through a needle valve to regulate the flow. The oxygen then passes through a tube to which is connected a mercury manometer and a hand pump fitted with a release valve, and then on to the double two-way tap of the apparatus (Fig. 2). From the proximal part of the double two-way tap it passes to one of the bottles. The blood is forced out of the bottle through the distal part of the
two-way tap and along a length of semi-transparent plastic tubing to the patient. When
the bottle is almost empty the tap is turned through 90 degrees and the flow continues without
interruption from the second bottle. The first bottle can then be replaced by a full bottle
while the second bottle is in use. The hand pump is used if the oxygen supply fails, and the
release valve lowers the pressure should it become excessive. A simple "Record" nozzle is
fitted to the end of the tubing. The needle need not be locked in position or tied to the nozzle.
Long wide-bore needles are used. The apparatus is mounted on a mobile trolley. The tubing,
tap, bottle attachments and needles are autoclaved and kept assembled in the theatre ready
for an emergency.

The apparatus is assembled with two bottles of blood. The tubing distal to the bottles
is filled with blood by gravity before the oxygen tube is attached to the cylinder.

The chosen artery is exposed and the needle inserted pointing proximally. The nozzle
of the apparatus is connected to the needle and the flow of blood controlled by the pressure
of the oxygen in the bottle, which in turn is controlled by the needle valve. This pressure
need seldom be higher than two hundred millimetres of mercury. The pressure can be kept
constant, and the changes of pressure that occur when a hand pump is used are avoided.
The rate of flow can be determined from the rate of fall of the blood in the bottle.

Two arteries have been used, the radial artery at the wrist and the femoral artery in
Scarpa's triangle. Any large artery may be used if it is exposed by the injury or at operation.
When the radial artery was used it was ligated above and below the site of injection and
divided. Firm packing of the wound was sufficient to stop bleeding from the femoral artery
after withdrawal of the needle.

**CHOICE OF ARTERY AND INCIDENCE OF COMPLICATIONS**

Both sites have their advantages and disadvantages. The radial artery can be exposed
quickly and if necessary ligated without great risk of ischaemia, and a needle can be controlled
more easily in this vessel than in the deep-seated femoral artery. On the other hand, because
of the difference in calibre of the vessels, the rate of flow possible in the radial artery is less
than in the femoral. Ischaemic changes were more frequent when the radial artery at the
wrist was used; they varied from patchy cyanosis of the skin of the forearm to transient
anaesthesia and paralysis of the forearm and hand muscles. No permanent vascular
complication occurred.

Several cases of gangrene of the hand complicating intra-arterial transfusion through
the radial artery have been reported (Holden 1952; Porter et al. 1948; Yee, Westdahl and
Wilson 1962). Comparison of these cases with that of the large series of uncomplicated
transfusions of Brown (1953) suggests several factors in the causation of ischaemia. 1) Citrated
blood stored for two weeks and injected at low temperatures tends to cause anoxia of the
local tissues because both the storage (Valtis and Kennedy 1953) and the temperature
(Barcroft and King 1909) reduce the amount of oxygen made available from the blood.
Brown (1953) used fresh warm blood. 2) Intra-arterial injection of cold blood may cause
arterial spasm (Holden 1952). 3) A duration of the transfusion exceeding two hours (Porter
et al. 1948). 4) Injection of fluids other than blood (Brown 1953). 5) Congenital absence of
an anastomosis between the radial and ulnar arteries in the hand.

**CASE REPORTS**

**Case 1**—The patient, a man aged forty-seven, sustained multiple compound fractures of both
legs by the bursting of a cylinder of air at a pressure of a thousand pounds per square inch. On
admission to hospital his blood pressure could not be recorded and respirations were slow and
sighing. He was placed in an oxygen tent and given an intravenous transfusion of 1,000 millilitres
of plasma followed by 1,000 millilitres of blood. During this time no improvement in his condition
occurred. An intra-arterial transfusion of 1,000 millilitres was then given by the left radial artery
in fifteen minutes (Fig. 4). During the transfusion his general condition began to improve and
the pulse quickly became palpable. At the end of the transfusion the blood pressure was 100 millimetres mercury and the patient was taking an interest in his surroundings and answering questions. During the transfusion the forearm and hand were found to be anaesthetic, the skin was cyanosed in patches, and the muscles paralysed. The condition of the limb slowly recovered to normal during the thirty minutes immediately after the transfusion.

An above-knee amputation of the right thigh and wound toilet and plaster fixation of the left were carried out initially, but a below-knee amputation of the left leg was required after two days. The patient has now returned to his previous employment, walking well with artificial limbs.

**Case 2**—Man aged thirty-two. This patient was involved in the same accident as the patient in Case 1. He sustained a traumatic amputation high in the left thigh, and a large degloving injury of the right thigh and knee. On admission his general condition was better than that of the other patient. He was given 1,000 millilitres of plasma followed by 1,000 millilitres of blood, but this did not stop a gradual deterioration of his condition. He was then given an intra-arterial transfusion of 1,000 millilitres of blood into the left radial artery with an excellent response, as shown in Figure 5. In this case patchy cyanosis of the forearm and hand was present during the transfusion. This passed off after the transfusion and no residual complication was present after twelve hours.

Suture of the stump of the left thigh and extensive split-skin grafting of the right leg were required. He is now back at work with a left artificial limb.

Both patients stated afterwards that they were conscious immediately after the accident, but did not remember any events thereafter until about the end of the intra-arterial transfusion.

**Case 3**—A woman of fifty-six was run over by a bus, sustaining severe fractures and soft-tissue injuries of both legs. For a year before the accident her general health had been poor. On admission to hospital she was pale and conscious, but neither her pulse nor blood pressure could be obtained. Although the patient appeared to be dying, she was placed in an oxygen tent and an intra-arterial transfusion of 2,000 millilitres of blood was given into the femoral artery of the most seriously injured leg. After this the blood pressure was recorded at 60 millimetres Hg. (Fig. 6), but the pulse was very rapid. Since her general condition had not improved as much as expected the transfusion into the femoral artery was stopped and after a short interval 1,000 millilitres of blood was given through the radial artery, but without any marked improvement in her condition. It appeared that the patient was in irreversible shock. A slow intravenous drip of plasma was set up, and four and a half hours after admission two milligrams of noradrenaline was added to it.
After this the blood pressure was 80 millimetres Hg., and the pulse was stronger. The intravenous plasma drip was continued, and nine hours after admission her blood pressure was 110 millimetres Hg., and she was then fit for operative treatment.

Slight patchy cyanosis of the skin of the volar aspect of the forearm was present during, and for one hour after, transfusion, but no reaction was seen in the leg.

The left leg was amputated above the knee and split-skin grafts were applied to the right leg. She later required further skin grafts to the right leg and for many months was mentally unstable. Eighteen months after the accident she is now much improved and is beginning to walk with a left artificial limb and a right caliper.

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REFERENCES


