

# Intraoperative autologous blood transfusion: report of a technique

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**Khan, R. M. A. and Bassett, H. F. M. (1975).** *Thorax*, 30, 447–451. **Intraoperative autologous blood transfusion: report of a technique.** Using a simple and relatively inexpensive technique, blood was salvaged during major thoracic and cardiovascular surgery in 34 cases. Detailed haematological, biochemical, and bacteriological studies were carried out, with red cell survival studies. It has been shown that cellular as well as non-cellular elements of the blood were well preserved with little or no bacterial contamination. It has been suggested that this form of autologous blood is a more suitable form of blood replacement than donor blood.

There is an ever increasing demand on the blood transfusion services for blood and its constituents. With improved techniques in serology, new and rare antigens and antibodies are being recognized. These present some real problems with regard to the blood donors. There are parts of the world where organization of blood transfusion services is inadequate. The hazards of blood transfusion using stored donor blood are well recognized. Furthermore, there may be theological objections to the use of donor blood.

Autotransfusion as a method of blood replacement was first suggested by Highmore about 100 years ago. It has been used increasingly in obstetrics (Butler, 1929; Maynard and Rees, 1929; Ricci and Di Palma, 1931; Tiber, 1934) and in surgery, including open-heart surgery (Wagstaffe, Clarke, and Jackson, 1972).

In most instances blood used for replacement was collected from the patients concerned several days before operation (Boerema and Fierstra, 1955; Cuello *et al.*, 1967; Daggett *et al.*, 1970). The blood lost during operative procedures was presumably discarded. It was not until the Vietnam war that Klebanoff (1970), using an apparatus for simultaneous aspiration, filtration, and reinfusion of the blood lost at operation, was able to operate on serious battle injuries and other emergencies. There are many parts of the world where indications for this form of blood replacement exist even during peace time.

Ideally, the technique for intraoperative auto-

logous blood replacement should be safe, simple, and relatively inexpensive. A technique of salvaging blood during major thoracic and cardiovascular surgical procedures is described.

## METHODS AND MATERIAL

Preliminary studies were carried out on 12 adults, four men and eight women (group 1). A standard suction system was used with high vacuum (up to –100 mmHg). The suction nozzles used were narrow with small areas of entry near their tips. Blood from the site of operation was collected in autoclaved transfusion bottles, each containing 1500 units of heparin.

Equipment and technique have evolved with experience. Joints are avoided, and the tubing itself is wide in diameter and short in length. For the present improved technique, which has been used in 22 adults, four men and 18 women (group 2), the following equipment is required: two lengths of plastic tubing, each approximately 45 cm long, with an internal diameter of 7 or 8 mm; a supply of standard transfusion bottles, each containing 100 ml of standard acid-citrate-dextrose (ACD) solution; a rubber bung with two holes, one large and one small, and a metal cannula.

This equipment is assembled by inserting the bung with the holes into the transfusion bottles. Two large side holes are cut out near the tip of one of the pieces of tubing, which is then used as the suction nozzle; its other end is introduced

through the larger hole of the bung. The other tube is connected to the metal cannula which is introduced through the smaller hole of the bung. This tube is connected to an adjustable suction unit set at  $-3$  to  $-5$  mmHg and shifting two litres of air per minute. The assembled unit (Fig. 1) is anchored to the drapes close to the site of operation.

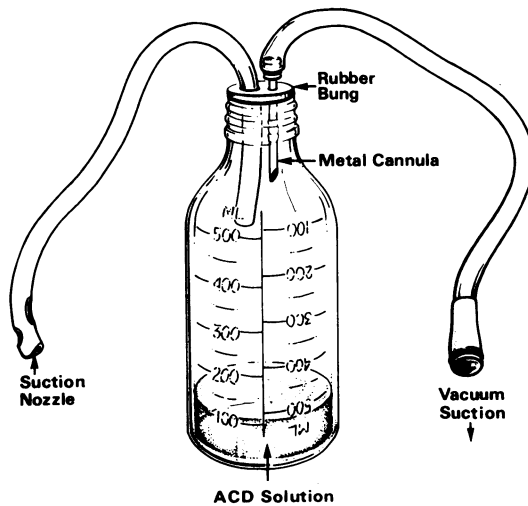


FIG. 1. The assembled unit for the salvage of autologous blood used in group 2 patients.

After opening the chest,  $0.5-1$  mg/kg body weight of heparin is given intravenously. This dose may have to be repeated at hourly intervals if the operation is long. The operative field is cleared of any blood clots, using high pressure 'discard' suction, before starting the process of salvaging the blood. The suction nozzle is now placed in an area where most of the blood is likely to collect. From time to time the bottle is shaken gently to allow mixing of the blood with ACD solution. Once the bottle is full, the rubber bung with tubes in situ is transferred to the next bottle and the process of blood collection is continued.

In case of sudden loss of a large volume of blood, suction can be increased up to  $-5$  mmHg and later turned down to  $-3$  mmHg as soon as possible. Whenever a potentially infected organ, such as the oesophagus or bronchus is opened, the process of blood collection is discontinued. The suction is turned off when there is evidence of adequate haemostasis.

The use of swabs is avoided as far as possible.

High pressure 'discard' suction is used very sparingly. No protamine is given at the end of the operation as it has been found to be unnecessary with the dosage of heparin used. The salvaged blood is now run through an ordinary blood giving set with its own filtration chamber. The last few millilitres of blood are discarded to avoid fat particles.

In this study samples of filtered blood were taken for detailed haematological studies—morphological appearances of the film, alteration in red and white cells, and presence or absence of clots, foreign tissue or material. Free haemoglobin and fibrinogen were estimated and platelets were counted. Red cell survival studies were carried out by labelling them with  $^{51}\text{Cr}$  in 12 randomly selected cases, using a technique described by Garby and Mollison (1971). Potassium ( $\text{K}^+$ ) was estimated in the plasma of the salvaged blood and compared with preoperative levels. Further 5 ml samples of blood were taken into blood-culture bottles, one with a Castenada-type medium, the other containing thioglycolate broth to estimate bacterial contamination.

## RESULTS

The results of preliminary high vacuum studies of group 1 are shown in Table I. Only 27% of the blood was salvaged and the rest was discarded, mainly in the form of clots. There were fine clots present even in the salvaged blood, with evidence of excessive destruction of cellular as well as non cellular elements of blood.  $\text{K}^+$  in the salvaged blood (mean  $4.9$  mmol/l) was higher than preoperative levels (mean  $4.0$  mmol/l). Free plasma haemoglobin was high (mean  $535$  mg/dl). Platelets and fibrinogen were very poorly preserved.

Table II shows the results of the present technique using the changes brought in since the preliminary studies, including the use of systemic heparin. The blood salvaged was 77% of the operative losses. In 14 out of 22 cases (64%) the blood discarded was less than 100 ml. The red and white cells were well preserved with no evidence

TABLE I  
DETAILS OF PRELIMINARY STUDIES USING STANDARD HIGH VACUUM SUCTION IN 12 PATIENTS (GROUP 1)

	Age (yr)	Blood Salvaged %	Platelets /mm <sup>3</sup>	Fibrinogen (mg/dl)	Plasma Hb (mg/dl)
Range	43-64	19-38	—	< 50-136	240-696
Mean	52	27	< 10 000	70	535
± SE	—	1.6	—	11.7	120

SE = standard error.

TABLE II  
DETAILS OF CASES STUDIED IN GROUP 2

Case No.	Age (yr)	Sex	Operative Blood Loss		Blood Salvaged %	Platelets /mm <sup>3</sup>	Fibrinogen (mg/dl)	Plasma Hb (mg/dl)
			Discarded (ml)	Salvaged (ml)				
1	43	F	< 100	300	75	—	—	—
2	53	F	< 100	450	82	39 000	141	53
3	40	M	300	600	67	75 000	328	292
4	69	F	350	750	68	—	< 50	260
5	37	F	< 100	450	82	36 000	139	158
6	35	F	250	1100	81	102 000	230	56
7	59	F	< 100	350	78	77 000	103	175
8	54	F	200	800	80	50 000	—	41
9	52	F	400	450	82	50 000	—	—
10	40	F	200	1300	87	61 000	135	53
11	50	F	200	700	78	55 000	207	220
12	56	F	< 100	450	82	91 000	366	218
13	59	F	< 100	400	75	85 000	158	178
14	45	M	< 100	320	77	70 000	211	188
15	54	F	< 100	350	78	94 000	< 50	107
16	37	F	< 100	300	75	50 000	158	92
17	53	M	< 100	1000	90	124 000	204	90
18	30	F	< 100	200	67	63 000	132	40
19	42	M	< 100	350	78	86 000	215	215
20	51	F	< 100	450	82	81 000	246	270
21	63	F	350	700	67	108 000	186	225
22	53	F	< 100	200	67	57 000	66	252
Range	30-61	—	—	—	67-90	39 000-124 000	< 50-366	40-292
Mean	49	—	—	—	77	73 000	174	159
± SE	—	—	—	—	1.4	5.2	1.9	18.9

SE=standard error.

of clots in the film. Red cells haemolysis was reduced, thus reducing the plasma haemoglobin (mean 159 mg/dl) as well as K<sup>+</sup> (mean 3.4 mmol/l), which was very little different from preoperative levels (mean 3.9 mmol/l). In eight out of 19 cases (42%) the fibrinogen was found to be within normal limits (mean 174 mg/dl). The platelets were also relatively well preserved (mean 73 000/mm<sup>3</sup>).

Bacteriological cultures produced no growth on initial or serial subcultures in seven out of 22 cases (32%). Although in the remaining 15 cases (68%) contaminants were grown in only one of the two media used on initial culture, serial subcultures of these media produced no additional organisms. The organisms which were found were diphtheroids and *Staphylococcus albus* and almost certainly represented contamination during subsequent handling of the samples.

The red cell survival studies showed that the mean half life (T<sub>50</sub>) of the salvaged red cells was 21 days (range 15-33). This compares favourably with the T<sub>50</sub> of normal, fresh red cells (mean 30 days, range 25-33) as shown by Garby and Mollison (1971).

DISCUSSION

Although autotransfusion as a method of blood replacement has been practised on innumerable occasions in the past, there are very few reports in the literature where blood lost during operative procedures has been salvaged and reinfused (Dyer,

1966; Wilson and Taswell, 1968; Klebanoff, 1970).

During preliminary studies in group 1 patients it became obvious that only 27% of the operative loss was being salvaged and that this was unsuitable for reinfusion. At this stage it was decided reluctantly to use systemic heparin. However, its use has not made any appreciable difference to the intra and postoperative blood losses; with its use it was possible to salvage up to 90% of the operative blood loss. The discard of less than 100 ml of blood in the presence of large or small operative loss was fairly constant, as observed in 14 out of 22 cases (64%).

Excessive trauma to various elements of blood, observed in group 1 patients, was reduced by lowering the negative pressure of the suction, by bringing the whole unit close to the site of operation and thus reducing the length of tubing, by avoiding unnecessary metal connections, and by using wide bore suction nozzles with larger side holes to allow larger areas of entry. Similar observations were made by Osborn *et al.* (1962). The use of roller pumps has been avoided since it has been shown that their use increases red cell haemolysis (Benzing, De Forest, and Kaplan, 1966).

This form of blood replacement has many advantages. A patient's own blood is the only truly compatible blood and strain on the transfusion services is reduced as no grouping and cross-matching is required.

A distinct advantage of autologous blood is the availability of well preserved platelets and fibrinogen; indeed there is some indication that when blood losses are greater the platelets and fibrinogen may be preserved more efficiently. When there is a large loss and replacement, abundance or deficiency of these essential factors could be crucial. Wagstaffe *et al.* (1972) have shown that by using fresh autologous blood after cardiopulmonary bypass and restoring the platelet level they have been able to reduce postoperative blood loss.

It is obvious from the results that serious bacteriological infection can be avoided since the organisms were isolated from only one of the two media used and no further growth was obtained on serial subcultures. It is quite probable that this was contamination introduced during the postoperative studies. This impression has been further substantiated by the results in 16 cases investigated after the conclusion of this preliminary study, as all clinical, haematological, and bacteriological studies have consistently shown no evidence of infection following the reinfusion of intraoperatively salvaged blood.

Up to 90% of the operative loss can be salvaged with minimal trauma to the blood and little or no bacterial contamination and reinfused to the patient. Efforts are being made to improve the technique further, including the use of a prototype autologous blood salvage unit. The two

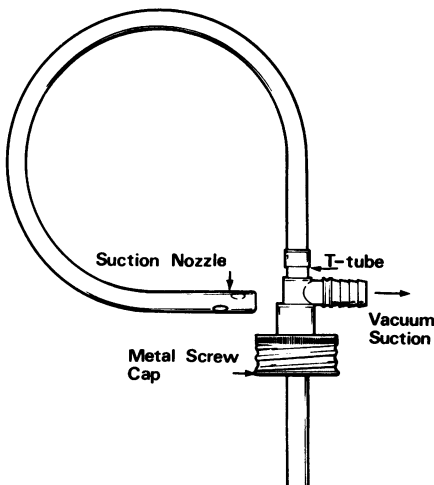


FIG. 2. This shows the new prototype blood salvage unit.

essential aims of this method continue to be simplicity and low cost.

We wish to thank Mr. Kenneth Bloor for allowing us to study the cases under his care, Dr. J. A. Tooth for assessment of bacteriological contamination, Miss Mulrayn and Miss Bottomley for their help with the haematological studies, the Department of Medical Illustration for Fig. 1, Mrs. Vera Thornton and Mrs. P. Dalby for secretarial assistance, and lastly—but not the least—the nursing staff of the Cardiac Surgery Unit for their hard work.

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ADDENDUM

Charles F. Thackray Ltd. have produced a relatively inexpensive autologous intraoperative blood salvage

unit to our specifications. Figure 2 shows the assembled unit which consists of a metal screw cap, incorporating a rubber bung with a large central hole for one limb of a T tube and a length of tubing as before which is introduced through the horizontal limb of the T tube. The other end of the tubing is used as a suction nozzle. There are no joints or interruptions in the tubing.

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