and this may take several months. Inquiry must then be made in order to discover which side of the family is affected and which members on the affected side have inherited porphyria. The urine of the relatives should be examined spectroscopically for porphyrins. It must not be forgotten that the syndrome will present in different ways in different members of the group. Many will have complained of symptoms the cause of which will not have been known. The doctor will be greatly rewarded when he makes the correct diagnosis in a patient who has long been regarded as neurotic, and who has had perhaps a number of operations on account of abdominal pains. All affected members of the group must be interviewed. Porphyrics should be given a letter stating the evidence on which the diagnosis has been made, and mentioning the danger of barbiturates and other drugs in this condition. They should show this letter to any doctor they may consult in the future.

Summary

Porphyria, a serious familial disorder, is common in South Africa.

In the chronic or latent stage the diagnosis will be made only if the doctor is alive to the possibility that the disorder may cause symptoms which are apparently neurotic, particularly abdominal pains.

In the latent stage no reliance can be placed on a negative urine test, as at this stage excess porphyrins may not be excreted. Diagnosis depends on a full personal and family history. During an acute attack examination of the urine will confirm the presence of porphyrins.

In acute attacks of obscure abdominal pain the abdomen should be opened only if there are definite indications that surgery is necessary, and after the urine has been carefully examined for porphyrins.

The increased use of barbiturates in the routine treatment of nervous disorders may well be responsible for bringing this syndrome to the fore. Intravenous barbiturate anaesthetics are particularly likely to precipitate a severe attack, often with resultant paralysis.

If one case of porphyria is diagnosed it is the doctor's responsibility to go very fully into the family history and interview as many relations as possible. This will lead to the discovery of other undiagnosed cases and result in preventing much suffering and unnecessary operations.

In the relatives of the cases described here, different manifestations of the syndrome were seen in different members of the family group. This suggests the unitary nature of porphyria in the adult, and that division into subtypes is artificial.

I would like to thank the doctors who called me in consultation to see these patients for their permission to publish the case histories, and for their unfailing help and encouragement in the preparation of this article. Also Mr. Barnes, of the South African Institute for Medical Research, Johannesburg, for investigating many specimens of urine for me. My thanks are also due to Dr. Harington and the staff of the Research Institute, Port Elizabeth.

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INTRA-ARTERIAL TRANSFUSION

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Intra-arterial transfusion is considered to be of great value in the treatment of haemorrhage. We agree that this is the main indication for its use, but the object of this paper is to report our observations on the value of the method in combating circulatory collapse due mainly to causes other than bleeding. An excellent survey, historical, experimental, and clinical, of the literature concerning the use of the intra-arterial route for transfusion has been published by Seeley and Nelson (1952). Valuable experimental and clinical evidence is given by Porter *et al.* (1948), Robertson *et al.* (1948), Jones *et al.* (1950), and Bingham (1952), among many others.

In general, where the effect of peripheral anoxia has been sufficient to cause relaxation of peripheral vessels and an increase in the volume of the vascular bed, with stagnation of the blood flow, fluids given intravenously will tend to accumulate in the relaxed venous channels. Vasopressors are often ineffective in restoring tone to the anoxic vessels, prolonged hypotension may have led to myocardial damage, and venous congestion may be present. Intra-arterial transfusion may even then restore the blood flow enough to reverse stagnation and permit adequate tissue oxygenation once more. When bleeding is not the cause of the collapse, such an improvement is only a respite during which definitive treatment may be applied, but it is an essential respite.

Apparatus

In brief, the method of intra-arterial infusion consists in the introduction of whole blood or blood substitutes under pressure into a suitable artery.

The apparatus* may be a simple transfusion set with a double bellows as the source of pressure, or take a more complicated form incorporating a manometer for measuring the infusion pressure. An oxygen tank with control valve is used as the motive force in some apparatus. If vasospasm is pronounced, a syringe and three-way stopcock are used.

*Since this paper was written we have used a form of rotary roller pump for rapid transfusions, and have found it superior to the apparatus described, and less apt to provoke vasospasm.

FIG. 1.—Apparatus for intra-arterial transfusion. 1=Air reservoir. 2=Blood. 3=Safety screw caps. 4=Aneroid manometer. 5=Sphygmomanometer bulb. 6=Drip chamber with float (Macintosh and Pask, 1941).

ful; the intermittent pressure of this method may provoke less reflex spasm of the vessel in response to the reversed circulation. This method is less prone to the danger of air embolism, a disaster which, when using a pressure drip, is prevented only by constant vigilance on the part of the administrator and by the use of a safety drip chamber with a float which beds down and produces an air-tight seal should the chamber become empty (Macintosh and Pask, 1941).

We have modified the apparatus described by Seeley (1951) to include such a drip chamber (Fig. 1). The set, less the pressure bulb and manometer, is autoclaved and kept in a sterile drum. For use, a saline bottle is emptied and attached as the air reservoir, the blood bottle being fixed to the other cork. Screw caps fitting the standard M.R.C. bottles are incorporated in the apparatus to prevent ejection of the corks by positive pressure.

Choice of Artery

The artery used for transfusion has varied with different authors; the radial, femoral, dorsalis pedis, or posterior tibial arteries, and the abdominal aorta have all been used. In the case of arterial bleeding, the site of transfusion should obviously not be distal to the point of haemorrhage. We prefer the left radial artery for the following reasons. The limb is almost always readily accessible, and good arterial anastomosis is available in the hand and arm to provide alternative channels should the vessel be sacrificed. It is easy to perform a sympathetic block to relieve vasospasm in this region, and the anatomical landmarks make identification of the radial artery at the wrist a simple matter.

In extreme shock, with the pulse impalpable and the vasospasm marked, percutaneous arterial puncture is likely to be almost impossible, and there is always a risk of haemorrhage after the withdrawal of the needle. Consequently, we prefer open exposure of the radial artery and ligation at the end of the transfusion, believing that there is no objection to such a course in this situation, and, further, that even if arterial suture were performed subsequent thrombosis would commonly occur.

Technique of Intra-arterial Transfusion

A preliminary brachial plexus or stellate ganglion block with 20 ml. of 1% lignocaine hydrochloride is performed if the urgency of the case permits. The skin of the left wrist is cleaned with ether and the area towelled up. Then 2 ml. of 2% procaine is infiltrated over the site of the radial artery, an incision is made—longitudinal if the vessel is palpable, transverse if not—and the artery exposed. A swab soaked in 2% procaine is laid over it while the apparatus is set up. Next, two ligatures are passed around the vessel and the distal one is tied. A V-shaped nick is made in the vessel and the cannula inserted, directed towards the heart. The proximal ligature is then tied to secure the cannula and 2 ml. of 2% procaine is injected into the artery via the drip tubing and the infusion begun. The rate and pressure at which transfusion is conducted will vary from patient to patient, and will depend upon the arterial blood pressure and the degree of arterial spasm. If the blood pressure is low and spasm is not pronounced, the drip will run fast at first, gradually slowing as the arterial blood pressure returns to normal levels. An initial pressure gradient of 50 mm. Hg has been suggested as suitable. The volume of fluid needed will vary with the condition causing hypotension, but a satisfactory response and clinical improvement usually occur rapidly after as little as 250 ml. has been given; the final total has often been between 1 and 2 litres.

At the end of the transfusion a further 2 ml. of 2% procaine is injected, the cannula withdrawn, and the vessel ligated. The limb is kept cool if there is any evidence of defective circulation, and, in this case, further improvement may be gained by a 0.2% procaine drip intravenously and by repetition of the brachial plexus block.

We have not yet tried the local application of warm papaverine 1:80 or 1:40 solution as recommended by Kin-

month (1952). This may be more effective than procaine in relieving local vasospasm.

From a practical aspect there are, we think, two chief points to be considered: (1) has the method any great advantage to offer over the intravenous route; and (2) when should its use be considered? These problems are related, for in conditions of profound shock, in which theoretically intra-arterial infusion is of the most value, it may be extremely difficult to get an intravenous drip to run at all, and, indeed, the failure of intravenous therapy to produce benefit may well indicate the use of the arterial route. A third problem is the possibility of ischaemia due to damage to the artery used for transfusion. In the case of the radial artery it seems that if the patient makes a recovery from his hypotension and circulatory collapse, there is little to fear on this score.

TABLE I.—Summary of 17 Reports on the Use of Intra-arterial Transfusion

Author	No. of Cases	Reason for Transfusion	Survival	Initial B.P.	Route	Ischaemic Sequelae
Porter <i>et al.</i> (1948)	12	Haemorrhage, 8 Coarctation of aorta, 4	5 4	0	Radial	1. Gangrene 2. Blistering of skin 2. Discoloration of skin
Robertson <i>et al.</i> (1948)	12	Haemorrhage, 10 Others, 2	8 0	Mostly 0	Post. tibial	—
Ciliberti and Dickler (1950)	1	Haemorrhage pulm. artery	1	0	Radial	Nil
Kay and Hacker (1947)	1	Haemorrhage int. mammary	1	0	Aorta	"
Haxton (1952)	10	Various, mainly haemorrhage	7	—	"	"
Bayles (1951)	1	Haemorrhage prostate	1	0	Radial	"
Gold <i>et al.</i> (1949)	1	Intestinal obstruction. High spinal	1	0	"	"
Jaquenoud (1952)	3	Haemorrhage, 2 Intestinal fistula, 1	0	—	"	—
Vignon (1952)	1	Haemorrhage, post-partum	1	0	"	Oedema and paralysis of arm
Silber <i>et al.</i> (1951)	9	Coronary thrombosis	2	0	"	—
Ziccardi and Madden (1951)	—	" Prophylaxis "	—	—	"	—
Bingham (1952)	100+	Shock and " prophylaxis "	—	—	"	2 Partial ischaemia of hand
French (1951)	2	Haemorrhage	2	0	"	1 Contracture of finger
Kohlstaedt and Page (1943)	3	Injury and haemorrhage	1	Below 50	"	2 Slough of skin of forearm
Metheny <i>et al.</i> (1949)	1	Ruptured aneurysm	0	60/50	Femoral	—
Devitt and Wigderow (1951)	1	Haemorrhage pelvic	1	0	Common iliac	Nil
Seeley (1951)	7	Haemorrhage, 3 Others, 4	2 2	Vary	Aorta, Radial, Femoral	"

Table I presents a summary of cases of intra-arterial transfusion collected from the literature. It will be seen that haemorrhage from various sites has formed the chief indication for therapy sometimes following the failure of intravenous transfusion to correct the hypertension, but often as the first choice. It is in this group, undoubtedly, that the results are best. Ischaemic sequelae were noted in only 10 cases, and were not seen in any of the cases of deliberate controlled hypertension by arterial bleeding and reinfusion, lending support to the view that the sustained return of the blood pressure to normal levels is a major factor in their prevention.

Discussion of Cases

Two patients were given intra-arterial blood because of haemorrhage (Table II).

Case 1.—A man aged 56 was admitted with severe haematemesis from a duodenal ulcer. The response to prolonged intravenous blood therapy was poor. He collapsed and became pulseless and comatose. Intra-arterial transfusion quickly improved his

TABLE II.—Cases Receiving Intra-arterial Transfusion

Case No.	Age	Condition	Initial		Vol. of Fluid	Time (min.)	Final		Result
			B.P.	Pulse			B.P.	Pulse	
1	56	Haematemesis from duodenal ulcer. No response to much blood I.V. Sudden collapse and coma	60/?	130	4,000 ml. blood	45	135/70	160	Duodenotomy—recovery. Partial gastrectomy for biliary leak three days later. Gradual deterioration. Died 4th post-operative day
2	60	Combined excision of rectum. Perineal haemorrhage	0/0	?	2,500 ml. blood	50	100/60	100	Operation completed. Recovery
3	61	Mesenteric embolus. Operative shock. Auricular fibrillation. Heart failure.	0/0	96	650 ml. blood	20	70/50	88	" " "
4	68	Volvulus of small gut. Heart failure. Pulmonary oedema. Peripheral failure	100/?	—	1,000 ml. blood	60	120/?	—	Improved. Pulmonary oedema less. No operation. Died 24 hours later.
5	42	Late perforated ulcer. Peripheral failure. Dyspnoea. Moribund	0/0	140	2,000 ml. blood	130	85/?	100	Suture of ulcer—prolonged hypotension. Temporary oliguria. Complete recovery
6	51	Peritonitis. Perforated duodenal ulcer. Peripheral circulatory failure. Moribund	0/0	—	1,000 ml. blood	20	100/80	—	Suture of ulcer. Died 9 hours post-operatively
7	19	Perforated ulcer. Comatose	0/0	150	800 ml. blood	70	—	—	Became conscious—sudden dyspnoea. Died during transfusion
8	50	Partial gastrectomy day before. Peripheral circulatory failure. Death imminent	0/0	160	2,000 ml. blood and dextran	55	85/?	—	Diagnosis in doubt. No operation. Died 8 hours later. Necropsy: Bleeding and leak from duodenal stump
9	50	Partial gastrectomy. Ileus. Peripheral circulatory failure. Sudden collapse	20/?	130	1,000 ml. blood	60	80/50	110	Initial improvement. Died 9 hours later
10	71	Oesophagectomy. Collapse 2nd day. Coma. Dyspnoea. Moribund	0/0	90	1,000 ml. blood	55	?	90	Slight response to transfusion. Died 30 minutes later
11	62	Partial gastrectomy. Peripheral circulatory failure 18 hours post-operatively. Moribund	90/?	130	1,500 ml. blood, 500 ml. dextran	75	120/60	130	Fair clinical response. Became conscious but relapsed. Terminal hyperpyrexia. Died 10 hours later
12	27	Ileus and intestinal obstruction following perforated appendix. Peripheral circulatory failure	65/55	124	1,000 ml. blood	30	100/60	124	Immediate laparotomy and enterostomy. (Local analgesia). Initial improvement. Died 5 days later

condition and he became conscious. Duodenotomy and the suture of bleeding vessels were performed. Post-operatively his condition was good, but he developed a duodenal fistula. After a subsequent partial gastrectomy he gradually deteriorated, and died in four days

Case 2.—A woman aged 60 was undergoing abdomino-perineal excision of the rectum for carcinoma when she suffered a torrential haemorrhage from the perineal wound. Blood pressure rapidly became immeasurable and the respiration all but failed. Artificial ventilation with oxygen was instituted and intra-arterial transfusion begun in the right common iliac artery. After the rapid infusion of 1,000 ml. of blood, the site of administration was changed to the left radial artery to allow the operation to proceed. A further 1,500 ml. of blood was given by this route. Left brachial plexus block was performed at the end of the operation. Next morning the blood pressure was 125/90 mm. Hg; pulse rate 80. The patient was rational and felt well. The left hand was normal apart from slight blanching of the finger-tips, which soon improved. She made a complete recovery.

In two cases there was apparently marked cardiac insufficiency.

Case 3.—A woman aged 61 in whom mesenteric embolus had been diagnosed. On examination, dyspnoeic at rest, rales at lung

FIG. 2.—Operative record of Case 3.

bases, heart enlarged to left, pulse rate 100, auricular fibrillation, blood pressure 116/60 mm. Hg. She was dehydrated. A slow intravenous drip of glucose-saline was begun pre-operatively. Laparotomy revealed gangrene of terminal ileum, caecum, and ascending colon. Progressive fall in blood pressure despite slow intravenous drip of dextran and blood (Fig. 2). Blood pressure not obtainable 35 minutes after induction. Good response to ouabain, 0.25 mg. intravenously, but not maintained. Further fall of blood pressure to zero, at 70 minutes. Patient cold and pale, aortic pulsation feebly palpable. Intra-arterial transfusion, 300 ml. in five minutes, produced a dramatic response. A further 350 ml. given during next 20 minutes with sustained improvement. Hemicolectomy was completed. The circulation in the hand was normal three hours post-operatively. The patient made a complete recovery. The collapse at operation was thought to be due to a combination of reduced circulating blood volume and insufficient coronary blood flow. The risk of precipitating congestive heart failure indicated the use of the intra-arterial route for rapid transfusion.

Case 4.—A man aged 68 had abdominal pain and distension for 54 hours, and perforated peptic ulcer was diagnosed. He was gravely ill, cyanosed, with evidence of heart failure and pulmonary oedema. After the intra-arterial transfusion of 1,000 ml. of blood his general condition was much improved. The pulmonary oedema was less. Treatment by continuous gastric aspiration was decided upon. His condition gradually deteriorated and death occurred 24 hours later. Necropsy revealed a volvulus of the small intestine.

Three moribund patients, suffering from peritonitis after perforation of a duodenal ulcer 24 hours or more before admission, were treated with intra-arterial blood transfusion.

Case 5.—A woman aged 42 had a perforation of a large acute duodenal ulcer, with gross peritoneal soiling. On admission she was collapsed, pulseless, cyanosed, and dyspnoeic; apex beat 140, blood pressure unobtainable. Continuous oxygen and intravenous therapy with blood was instituted immediately without improvement. Thirty-five minutes later an intra-arterial blood transfusion was begun in the left radial artery. Subsequent progress is shown in Fig. 3. On the first post-operative day the systolic blood pressure was only 70 mm. Hg. Urine output was 120 ml. The left hand was blue and cold. Left brachial plexus block was performed and 0.2% procaine given intravenously. By the second day the blood pressure was 104/70 mm. Hg. The urinary output was 180 ml. The left hand was pink and warm except for the first and second fingers. The urinary output gradually rose to 1,700 ml. on the sixth day. The blood urea had risen to 390 mg. per 100 ml. on the fifth day, but thereafter fell to normal. The left hand recovered completely and the patient was discharged from hospital on the 23rd post-operative day. The extremely satisfactory response to intra-arterial transfusion was.

followed by a deterioration in condition (Fig. 3), as operation was delayed. We feel that a decision to operate should be made as soon as there are signs of response to the intra-arterial transfusion, and the theatre prepared so that the operation can begin immediately the patient's condition warrants it. Delay may result in the optimum benefit being lost.

Case 6.—In this case, that of a woman aged 51, operation was also delayed (Fig. 4). There was a good response to intra-arterial transfusion, but the delay probably accounted for her deterioration during operation.

Case 7.—A girl aged 19 was comatose on admission with no recordable blood pressure. She regained consciousness and her condition improved; but she became suddenly dyspnoeic during the transfusion and died. Necropsy did not help to find the cause of this.

FIG. 3.—Pre-operative and operative record of Case 5.

FIG. 4.—Pre-operative and operative record of Case 6.

TABLE III.—Final State of Circulation in Limb Compared with Response to Transfusion

Case No.	Response to Transfusion	Outcome	State of Limb
1	Good	Died 7 days later	Normal
2	"	Recovered	Initial blanching of fingertips. Return to normal
3	"	"	Hand dusky for 3 hours
4	"	Died 24 hours later	Rapid return to normal
5	"	Recovered	Hand dusky. Rapid return to normal
12	"	Died 5 days later	Hand cold and cyanosed for 24 hours. Completely recovered, though nail of index finger separated
6	"	" 12 hours later	Hand dusky for 3 hours. Rapid return to normal
8	"	" 8 " "	Hand dusky but circulation satisfactory
9	"	" 9 " "	Hand cyanosed. Circulation fair
11	Fair	" 10 " "	Hand cyanosed and cold
7	Slight	" during transfusion	Cyanosed and cold
10	"	" 30 min. later	" " "

Cases 8–12 showed a gross hypotension and circulatory failure at some stage during the post-operative period.

Most were practically moribund, and intra-arterial transfusion was given as the only means of averting death. The response varied with the severity of the circulatory collapse, but was often good. One patient (Case 12) was improved enough to permit an emergency enterostomy for relief of post-operative intestinal obstruction, but, despite a good initial recovery, he died of bronchopneumonia five days later.

Table III correlates the state of the circulation in the limb used for intra-arterial transfusion with the response to transfusion and ultimate clinical progress. A temporary cyanosis of the hand or forearm was common, but the circulation improved rapidly in those cases showing general recovery. In only one case (No. 5) was there any grave doubt, but brachial plexus block and intravenous procaine gave improvement, and once her general condition became better there was no further cause for anxiety.

Conclusions

The complete recovery of even two patients out of ten suffering from extreme and apparently hopeless non-haemorrhagic shock, and the temporary improvement obtained in others, at least two of whom (Cases 4 and 8) might have recovered had operation been performed, seem to justify the use of intra-arterial transfusion in such cases. A respite is given to the patient, during which definitive treatment is made possible, which may lead to recovery.

When surgery is contemplated a decision must be made to operate as soon as enough benefit is obtained from the transfusion; delay may result in the optimum state being lost owing to subsequent deterioration in the patient's condition.

In purely haemorrhagic shock, normal circulatory levels will be more certainly and rapidly restored by intra-arterial transfusion than by the intravenous route, less blood should be needed, and operation can be undertaken promptly. This may prove of great value in certain cases—for example, massive gastro-intestinal haemorrhage, in which delay in waiting for improvement to occur inevitably involves the risk of further bleeding.

Summary

Twelve cases in which intra-arterial transfusion was given are presented. The technique of intra-arterial transfusion is described. A review of the literature shows that haemorrhage has formed the chief indication for the use of the method. The possible value of the treatment in the resuscitation of patients in extremis from other forms of shock is discussed.

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