Fluid replacement via the rectum for treatment of hypovolaemic shock in an animal model

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The rabbit may not be the ideal model to study fluid resuscitation by the rectal route

The study by Girisgin *et al*¹ is an unusual one for the *Emergency Medical Journal* as it is an animal study. It raises some interesting issues:

1. How valid is an animal model of haemorrhage?
2. How valid is a rabbit model when investigating gut absorption of fluids?
3. How valid is blood pressure as a biomarker of volume status?
4. Why investigate the rectal route for fluid resuscitation?

To paraphrase HB Stoner,² one of the fathers of trauma research in this country, a good animal model should fulfil certain criteria:

- It must be reproducible
- It must be measurable
- Its intensity must be controllable.

Models of haemorrhage may be classified into controlled and uncontrolled haemorrhages. Controlled haemorrhage may be either of the "Wiggers" type, in which blood is withdrawn until a specified hypotensive blood pressure is achieved,^{3,4} or of a fixed-volume type, in which a predetermined volume of blood is removed irrespective of the blood pressure response.⁵ Uncontrolled haemorrhage models involve the laceration of a major vessel—for example, a 4 mm tear of the aorta.⁶ Although the first two models may seem rather artificial compared with the third, they do fulfil Stoner's criteria, and the uncontrolled haemorrhage models have shown that with normal clotting, even tears to the aorta are not invariably fatal, so that the models then resemble the controlled haemorrhage models.

The model used by Girisgin *et al*,¹ in which rabbits were bled out about 30% of their circulating blood volume so that the mean arterial pressure was reduced to about 34% of baseline, fulfils the criteria

suggested by Stoner. It is not dissimilar to the model used by Komori *et al*,⁷ namely, a 40–50% blood volume loss to achieve a mean arterial pressure of 22%. It seems a reasonable model of severe but not catastrophic haemorrhage.

Is the rabbit a good model in which to examine the rectal administration of saline? This is a more difficult question to answer. Rabbits produce two types of faeces. At night they produce soft, moist, mucus-covered faeces that are immediately swallowed again and redigested. During the day, they produce the typical dry droppings. The whole process was described by Matthews⁸ as "refection". This behaviour is peculiar to lagomorphs (rabbits and hares) and some rodents. It arises out of the particular anatomy and function of their digestive tract.⁹ In fact, we now know that the "soft faeces" are pellets produced from partial fermentation in the caecum, called caecotrophs. These are ingested directly from the rectum. This caecotrophy is influenced by the pattern of food ingestion, light-dark cycles and whether the rabbits are wild or captive.^{9,10} The colon seems to vary greatly in its ability to absorb water. During caecotroph production, colonic transit times are 1.5–2.5 times faster than during true faeces production.⁹ Does this mean that rabbits are far more likely to respond to rectal fluids than other mammals? Certainly during the "hard faeces" part of their digestive cycle, they would seem to absorb much more fluid from the colon than during the "caecotroph phase". To fulfil Stoner's reproducibility criterion, it is essential to know that all the rabbits were in the same phase during the experiments. Another important characteristic of the rabbit colon is the fusus coli, the pacemaker for colonic peristalsis. It initiates peristalsis and may have a role in hormone regulation—for example, aldosterone levels are highest during hard faeces production.⁹ Fusus coli function is partly regulated by autonomic and adrenal factors. The stress

of haemorrhagic shock will almost certainly have an effect on colonic function. The rabbit may not be the ideal model for studying fluid administration via the rectum.

In a study that aims to model hypovolaemia and its amelioration with fluid resuscitation, it is surprising that mean arterial blood pressure is offered as the only biomarker of volume status and, indeed, the primary outcome measure of efficacy of fluid given by the rectal route. In the acute care setting, it has been established that blood pressure alone is a poor indicator of circulatory volume status and that more reliance should be placed on a range of clinical signs together, along with more objective surrogates of cardiac filling (such as central venous pressure) and cardiac output (eg, Doppler aortovelocity).¹¹ In the laboratory, these clinical approaches should be replicated as a minimum; consideration for direct assessment of circulatory volume also may be appropriate. For example, Girisgin *et al*¹ could have reported at least the pulse rate along with the blood pressure, and mapped how they changed as a ratio—the so-called "shock index"—which is a better clinical biomarker of volume status during haemorrhage or fluid resuscitation.¹¹ Further, the control group was apparently not exposed to rectal tube insertion, raising the possibility that blood pressure effects in the intervention group were not necessarily related to changes in the circulating volume status in response to rectal fluid administration. A more reliable approach to assess the circulating volume would have helped to resolve this study design problem.

Girisgin *et al*¹ suggest a rationale for fluid replacement by the rectum in hypovolaemic shock. The basic principle is not new. The administration of medicines by the rectal route dates back at least to the ancient Egyptians.¹² The popularity of enemas and suppositories has waxed and waned since then, and also varied geographically.¹³ However, the earliest reference to the use of rectal fluids for resuscitation seems to be in the "Report to the Surgeon General of the [US] Army in 1900". This contains an account of a soldier who was stabbed in the neck and exsanguinating but who was resuscitated, after ligation of the bleeding vessels, with normal salt solution given by the rectal and subcutaneous routes.¹⁴ Rectal enemas were proposed as a method of saline administration in patients with burns by Sneve in 1905.¹⁵ In the First World War, rectal fluids (generally normal saline) were used as an adjunct to blood transfusion,¹⁶ although Cannon¹⁷ later emphasised that,

"These observations on cases of haemorrhage are an indication of what may be done through simple measures in non-urgent cases of shock".

During the Korean War, there was renewed interest in the gastrointestinal route of fluid administration—namely, oral water—for mass casualty situations. A study on the absorption of deuterium oxide after oral administration concluded that:

Following burns of moderate extent or severe wounds of the chest and extremities, deuterium absorption is impaired but remains much more rapid than after abdominal injury ... Peripheral vascular collapse due to intra-abdominal injury is associated with only negligible absorption of deuterium.¹⁸

The rectal route is not mentioned in volume II of *Battle Casualties in Korea*, the volume detailing resuscitation.¹⁹

Hardaway²⁰ mentions the use of rectal fluids in the First World War in the introduction to his book, *Care of the wounded in Vietnam*, but again the technique is overlooked in favour of intravenous fluid resuscitation even in the most desperate circumstances.

It seems that rectal fluid resuscitation was used in an era when intravenous techniques were far less advanced than they are now, but even then, it was of secondary importance.

Why has the technique not survived? Probably, in military situations, the number of casualties was such that surgeons rapidly became so adept at venous cannulation and venous cut-downs that they had no need for less efficient routes of fluid administration. And there is no doubt that the rectal route is less efficient. Robertson and Bock¹⁶ suggested that up

to 500 ml of saline could be retained per hour, a quantity quite inadequate for many of the casualties reaching hospital during the Vietnam War.

From personal experience, patients who are so volume depleted and shut down that intravenous access is impossible are at or near to having a cardiac arrest. With the circulation almost at a standstill, rectal absorption of fluid is unlikely. The intraosseous route would probably offer the patient the best chance of survival. What then might be the place of rectal fluid resuscitation? When fluid is required in moderate hypotension in patients with no veins? In mass casualty situations? Or the rehydration of victims of drought? As an adjunct to blood transfusion? As suggested by Robertson and Bock,¹⁶ the technique of fluid replacement via the rectum may have a place in contemporary medicine, but it seems unlikely to have a role in the management of hypovolaemic shock.

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