CONTROL OF BLEEDING IN CEMENTED ARTHROPLASTY

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Bleeding from cancellous bone causes lamination within bone cement and at its prosthetic interfaces, and weakens the fixation of joint replacements. We examined the effects of anaesthesia and blood pressure on bleeding in human cancellous bone, and investigated the local response to freezing saline, 1:200 000 adrenaline and hydrogen peroxide.

Spinal anaesthesia reduced cancellous bleeding by an average of 44%, local freezing saline by 24%. Saline at room temperature, adrenaline solution and hydrogen peroxide each reduced it by 14%. The effects of spinal anaesthesia and of freezing saline were additive: used together they reduced bleeding by 56%. The reduction of blood contamination of cement and its interfaces should contribute to better prosthetic fixation.

Aseptic loosening is now the commonest cause of failure in total hip replacement; this results most frequently from mechanical failure at the bone cement interfaces. Blood lamination can reduce the strength of the cement-bone interface by 50% (Bannister and Miles 1988) and that of bone cement itself by up to 70% (Lee, Ling and Wrighton 1973; Gruen, Markolf and Amstutz 1976). Reduction of bone bleeding is therefore desirable but the best means of achieving this is not clear. Both systemic and local measures have been tried.

Hypotensive anaesthesia is advocated, but the level of systemic blood pressure correlates poorly with bleeding in human cancellous bone (Heyse-Moore and Ling 1983). The local application of thromboplastins arrests bleeding, but the resulting fibrin layer is interposed between cement and bone and weakens the interface (Lange 1979). Hydrogen peroxide (Hankin et al 1984) and adrenaline solution have been advocated; the former has been shown to reduce bleeding in the metaphysis of the canine knee. Studies in human cancellous bone have been confined to thromboplastic agents (Harris et al 1978) and aimed primarily at reducing the systemic effects of blood loss without impairing bone healing.

There appeared to be a need to arrest bleeding in

human cancellous bone without the formation of excessive amounts of fibrin. We have investigated the effects of spinal anaesthesia and changes in systemic blood pressure, the local action of freezing saline, adrenaline solution and hydrogen peroxide and the optimum duration of local application of such haemostatic solutions.

MATERIAL AND METHODS

As a model for the study we used the proximal femurs of patients who were undergoing primary hip replacement. For the purposes of the experiment, we had to establish the time at which the rate of femoral medullary bleeding became constant. Once this had been done, each femur could be used as its own control and the effect of different treatment variables on the rate of bleeding could be assessed.

In six patients an opened, dry 11 g swab was packed into the medullary cavity of the proximal femur after it had been reamed, curetted to the corticocancellous junction, cleaned with a brush and opened gauze swab, and a Hardinge high density polyethylene restrictor had been placed 15 cm distal to the amputated neck. The swab was left for one minute, then removed, weighed and replaced with another dry swab. The swabs were successively exchanged every minute for 10 minutes. The weight of blood absorbed could be obtained by subtraction and the rate of bleeding per minute established.

Once this rate had become nearly constant, a dry 11 g swab was inserted for one minute and weighed. This was followed by a swab soaked in one of the test solutions. After this had been removed, the medullary cavity was cleared of residual test solution and a further dry swab inserted for one minute. The difference in weight between

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the first and last swabs represented the effect of the test solution on bone bleeding. The test procedure lasted for about 3.5 minutes, during which the systemic blood pressure was recorded.

We tested freezing saline, saline at room temperature, adrenaline 1:200 000, and hydrogen peroxide (30%), using a random allocation. The type of anaesthesia was decided independently by the anaesthetist: just under half the patients received regional analgesia.

Finally, the most effective haemostatic solution was applied as pulsed lavage for one minute.

Statistical analysis. Data was analysed by Student's *t*-test and Spearman rank tests.

RESULTS

In all, 151 patients undergoing primary hip replacement were entered into the study; 83 had general and 68 spinal or epidural anaesthesia. Each of the four test groups had a similar distribution of general and regional anaesthesia; differences in mean blood pressures were not significant.

Constant bleeding time. The reactive bleeding after reaming was completed appeared to last for about one minute during which bleeding averaged 25 ml/min. The rate fell to a mean of 18 ml/min for the ensuing nine minutes. In the first minute, bleeding was significantly greater than the remainder of the period studied ($p < 0.05$). All tests with solutions were therefore carried out between two and 10 minutes after reaming.

Systemic effects. The initial rate of bleeding under general anaesthesia was 22 ml/min (range 3.5 to 70) and under regional block 12 ml/min (range 0 to 30); difference, $p < 0.001$. Cancellous bone bleeding was directly related to systolic blood pressure under general anaesthesia ($p < 0.001$), but not under regional anaesthesia; the latter appeared to reduce bleeding by an independent mode of action.

Local effects (Table I). Freezing saline reduced mean bleeding by 5.2 ml/min and was significantly more effective ($p < 0.05$) than 1:200 000 adrenaline solution (3.1 ml) saline (2.9 ml) or hydrogen peroxide (2.7 ml) at room temperature. Haemostatic solutions exerted their greatest effect on patients under general anaesthesia; they made less difference under regional analgesia. They were significantly more effective when initial blood loss had been high ($p < 0.001$).

Continuous lavage. When freezing saline was applied by continuous irrigation for one minute, it had no haemostatic effect, being significantly less effective than any solution at room temperature applied by swab for a similar period.

Reduction of bleeding (Table II). Bleeding from the cancellous bone of the medullary cavity of the proximal femur was almost halved by regional anaesthesia. Under general anaesthesia, it was reduced by a quarter by freezing saline, and by one seventh by any solution at room temperature applied and left for one minute. The

effects of regional anaesthesia and freezing saline were additive and reduced bleeding by 56%.

DISCUSSION

The first studies of the use of topical haemostatic agents were aimed at reducing the systemic effects of blood loss from bleeding cancellous bone surfaces (Cobden, Thrasher and Harris 1976; Harris et al 1978). This is rarely necessary in cemented joint replacement as these areas are occluded by the bone cement itself.

Our technique of measuring femoral bleeding was modified from previous studies (Hankin et al 1984). Inaccuracies may accrue from differences in the surface area of bleeding bone, the sensitivity of the spring balance used and variations in the weight of standard swabs.

Table I. Mean reduction of bleeding (ml/min) after packing for one minute with various solutions

Solution	Number	Reduction of bleeding	
		Mean	s.d.
Saline	34	2.9	5.2
Freezing saline	32	5.2	4.2
Hydrogen peroxide 30%	27	2.7	4.5
Adrenaline 1:200 000	30	3.1	4.7

Table II. Mean reduction of bleeding (*per cent*) produced by various local and systemic methods

	Reduction
Saline	13
Freezing saline	24
Hydrogen peroxide 30%	13
Adrenaline 1:200 000	15
Spinal or epidural anaesthesia	44
Spinal anaesthesia and freezing saline	56

The greatest capacity to reduce cancellous bleeding lies outside the hands of surgeons; it rests with their anaesthetists. Regional anaesthesia offers the best prospect of reducing bleeding, but the use of hypotensive agents in general anaesthesia also has potential benefits.

We found that the physical properties of freezing saline reduce bleeding more than the pharmacological effects of adrenaline or hydrogen peroxide. It is possible that a low temperature solution might damage osteocytes,

but reaming and the insertion of bone cement (Rhineland et al 1979) probably have a greater effect. There are clear benefits from packing the proximal femur with a swab soaked in a solution at room temperature rather than using repeated irrigation up to the time of cement insertion.

Contamination with blood is a major problem in the quest for better prosthetic fixation. The use of cement of appropriate viscosity (Benjamin et al 1987) and the removal of bone debris (Halawa et al 1978) are also important, but the reduction of bleeding from cancellous bone can only improve fixation.

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