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THE EFFECT OF METHYL METHACRYLATE CEMENT ON THE BLOOD PRESSURE

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Acrylic cement is frequently used for fixing the prostheses in the operation of total hip replacement in patients suffering from osteoarthritis or rheumatoid arthritis (Charnley 1972). Attention has been drawn to the effects of methyl methacrylate cement on the blood pressure, and it has been stated that a fall in systolic blood pressure occurs commonly after the introduction of cement into the proximal end of the femur (Frost 1970, Harris 1970, Gresham et al. 1970). We have found a different effect. We have observed the changes in blood pressure after implantation of the cement in both the acetabulum and the femur and have related these to changes in the concentration of anaesthetic agents used and to the rise or fall of the blood pressure before implantation.

MATERIAL AND METHODS

The 45 patients in this study, aged between 51 and 84 years, were being treated for osteoarthritis or rheumatoid arthritis of the hip joint. A Charnley prosthesis (Charnley 1961) was inserted in 36 cases and a McKee-Farrar prosthesis in 9 (McKee 1967). The acrylic cement was Surgical Simplex - P. Most patients were operated on in the lateral position, with 10° of head-down tilt. The approach to the hip was lateral or antero-lateral.

The blood pressure was measured with an oscillotonometer connected to a pneumatic cuff on the upper arm. It was recorded at five or ten minute intervals during the operation and at intervals of a minute or less before, during and after insertion of the cement and the prosthesis. The pulse rate was recorded at similar intervals. Blood loss, from incision until reduction of the prostheses, never exceeded 250 ml, and transfusion of blood was not begun until the artificial joint was reduced and further bleeding had occurred. Intravenous dextrose saline was given slowly throughout the operation. The time when a drug was given or when the concentration of halothane was changed was recorded.

Anaesthesia

Neuroleptanalgesia supplemented by light general anaesthesia was used to maintain a stable and responsive cardiovascular system (Aubry et al. 1966). The same anaesthetist (H. C. B.) gave all the anaesthetics and the depth of anaesthesia was similar. All patients were premedicated with droperidol 10 mg and pethidine 50 mg, given intramuscularly 60 to 90 minutes before operation.

A combination of the following drugs was given for induction:

1. Droperidol: 15–20 mg.
2. Phenoperidine hydrochloride: 1–2 mg or fentanyl: 0.15–0.5 mg.
3. Methohexitone sodium: 30–50 mg.
4. Atropine: 0.3–0.6 mg.
5. Alcuronium chloride: 10 mg or pancuronium bromide: 4–6 mg.

The patients were intubated and respired mechanically by intermittent positive pressure, using a mixture of nitrous oxide and oxygen in the proportions 50:50 or 60:40. The ventilation volume was 600 to 800 ml at a respiratory rate of 13 per minute.

Halothane was added to the gas mixture in concentrations of 0.5 to 1.0 per cent to maintain the systolic blood pressure between 100 and 120 mm of mercury. Supplements of phenoperidine hydrochloride or fentanyl were given if a concentration of 2.5 per cent of halothane was needed to maintain this pressure.

RESULTS

Changes in blood pressure took place within the first five minutes after cement implantation. The first change in systolic pressure in response to the insertion of cement is termed "initial response". The initial response of the systolic pressure when the acetabulum was packed with cement was a rise in 16 patients, a fall in 24 and no change in 5. When the femur was packed with cement the systolic pressure initially rose in 24 patients, fell in 20 and there was no change in blood pressure in 1. After the initial response there was sometimes a change in the state of the pressure. Thus in the acetabular stage, of the 16 that showed an initial rise 8 then fell, and of the 24 that initially fell, 12 then rose. In the femoral stage 14 rose only, 10 rose then fell, 4 fell only and 16 fell and then rose.

There is an "overall rise" when the pressure after five minutes is still above the systolic pressure at the time of the implantation. There was an overall rise in 18 operations at the acetabular stage and 31 at the femoral stage; an overall fall in 15 at the acetabular stage and 10 at the femoral stage. These results are shown in Table 1. The maximum rise in systolic pressure in a patient was 25 mm of mercury at the acetabular stage and the average rise in all patients whose pres-

sure rose at all at the acetabular stage was 12 mm of mercury. The respective figures for the femoral stage were maximum rise 53 mm and average rise 25 mm. The maximum fall in a patient was 22 mm of mercury for the acetabular stage (average 9 mm) and 40 mm for the femoral stage (average 13 mm).

Table 1. Changes in the systolic blood pressure during the five minutes after cement implantation.

Effect on systolic blood pressure	Number of patients	
	Acetabulum	Femur
Overall rise in 5 minutes	18	31
Overall fall in 5 minutes	15	10
Initial rise	16	24
Initial fall	24	20
Rise only	8	14
Fall only	12	4
No change	5	1

When the cement was implanted in the acetabulum or the femur there were two other variable factors, the state of the systolic blood pressure before implantation and the concentration of halothane being administered to the patient. There was minimal bleeding at these stages of the operation and blood was not being given. To determine if the implantation of cement had any effect and what that effect was, the systolic blood pressure changes must be examined when the halothane concentration was unchanged, and note must be taken of the state of the pressure before implantation, for a falling blood pressure that rises after implantation is of more significance than a rising pressure that continues to rise.

Table 2 records the initial response of the systolic blood pressure when the pressure alone was a variable, and the effect of a change in halothane concentration (an increase in halothane concentration causes the systolic pressure to fall and vice versa). At the acetabular stage, when the systolic pressure was rising, it usually continued to rise after the cement was introduced. If it was steady or falling, it rose or fell equally often. This difference is significant (an exact χ^2 gives a probability of 0.009) and demonstrates that the state of the blood pressure influences the effect of the cement implantation. At the femoral stage the implantation had a more definite effect, causing

Table 2. The initial response of the systolic blood pressure after insertion of the cement.

Systolic blood pressure before cement		Initial response					
		Acetabulum			Femur		
		rise	fall	steady	rise	fall	steady
Falling	B.P. alone	4	6	2	8	6	0
	Halothane effect	3	8	0	0	0	0
	total	7	14	2	8	6	0
Rising	B.P. alone	5	1	0	11	4	0
	Halothane effect	1	2	1	1	0	0
	total	6	3	1	12	4	0
Steady	B.P. alone	3	4	1	4	7	1
	Halothane effect	0	3	1	0	3	0
	total	3	7	2	4	10	1

(‘B.P. alone’ means there was no change in halothane concentration.

(‘Halothane effect’ means a change in halothane concentration could have caused the blood pressure change.)

a pressure rise, and though the systolic pressure state before implantation appeared to have some influence it is not statistically significant ($\chi^2 = 1.53$; $DF = 1$; $0.30 > P > 0.20$). The response to halothane at the acetabular stage demonstrates that the blood pressure changes are influenced neither by the state of the pressure before implantation nor by the implantation itself. Such variations as there are are not significant ($\chi^2 = 0.46$). The number of cases of “halothane effect” at the femoral stage are too few for analysis. The pre-operative blood pressure was irrelevant and neither the pulse rate nor the diastolic pressure was affected.

DISCUSSION

Phillips et al. (1971) noted a fall of 10 mm of mercury or more in 16 out of 20 patients studied during the femoral stage, but found little effect during the acetabular stage, apart from one case in which there was a rise of 50 mm of mercury. Thomas et al. (1971) reported a fall

in every operation following one or both insertions of cement, occurring within one to three minutes. Charnley (1970) states that a noticeable fall occurs in less than a third of cases and in a few there is a small rise.

Our measurements in 45 patients show that during the acetabular stage a rise or a fall in pressure is influenced by the state of the blood pressure immediately before the cement is introduced and by a change in halothane concentration. With the insertion of the cement for the femoral prosthesis there may be a larger rise in the systolic blood pressure up to 53 mm of mercury and there is a greater tendency for the pressure to rise, but this also may be modified by the state of blood pressure before insertion.

The main difference between the operations that our patients underwent and those of Phillips et al. (1971) and Thomas et al. (1971) lay in the form of anaesthesia used. Our patients received phenoperidine and droperidol to enhance the analgesia, and this may have altered the response of their cardiovascular systems to the stimulus of the implantation of cement and a prosthesis. This stimulus could be thermal, mechanical or chemical.

The thermal effect could be an important factor, for temperatures in the curing cement may rise to 70° to 100°C, as reported by Bloch et al. (1970) and Homsy et al. (1969), although the maximum temperature is reached after the changes in blood pressure have occurred. High intramedullary pressures approaching 2,000 mm of mercury have been recorded by Phillips and his co-workers (1972) when cement is packed into the femoral shaft, whether or not a vent is used, but there is a similar intramedullary pressure rise when the femoral prosthesis is inserted and no individual effect on the blood pressure at that time has been noted, so this mechanical stimulus may not be the cause. Bloch et al. (1970) have found monomer in some venous blood samples taken from patients undergoing total hip replacement operations, using gas chromatography. Homsy et al. (1969), using ¹⁴C tagged monomer in dogs, found monomer in the central circulation immediately after cement was implanted in the femoral shaft, but direct injection of monomer intravenously caused only a brief and small fall in blood pressure for small quantities injected, although healing haemorrhagic lesions were later found in the lungs. These chemical effects are being investigated.

A change in the systolic blood pressure frequently occurs, but we have found no constant effect upon the diastolic pressure and the pulse

rate. Phillips et al. (1971) found no change in the pulse rate or central venous pressure, and Thomas et al. (1971) reported no change in central venous pressure and no toxic myocardial changes on the electrocardiogram. The cause of the blood pressure changes is unknown, but is modified by the patient's blood pressure state, by changes in halothane concentration and by using neuroleptanalgesia. The potentially dangerous effect of a sudden fall in pressure can be prevented by using the anaesthetic technique that we have described.

SUMMARY

In 45 patients undergoing total hip replacement the effect of the insertion of methyl methacrylate cement on the systolic blood pressure was influenced by the state of the blood pressure before implantation and by changes in the concentration of halothane in the anaesthetic gases. A dangerous fall in blood pressure was avoided by using neuroleptanalgesia.

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