Cardiovascular Effects of Implanted Acrylic Bone Cement

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Summary

A pilot study has shown that there is usually but not invariably a fall in systemic arterial blood pressure within 90 seconds of implanting acrylic cement into the femoral shaft during hip arthroplasty. There is usually no change in arterial blood pressure on implanting acrylic cement into the acetabulum. The observed hypotension may be due to absorption of monomer or additives into the circulation, but the role of other factors needs investigation.

Introduction

The introduction of cold curing acrylic cement to anchor the components of artificial joints to bone has revolutionized orthopaedic practice and is largely responsible for the popularity and success of major joint replacement. In spite of the very many operations which have involved the use of bone cement, reservations regarding its complete safety still exist. The recent reports of cardiac arrest occurring after the implantation of cement into bone (Powell *et al.*, 1970; Gresham *et al.*, 1971) and the fall in blood pressure frequently observed by others (Charnley, 1970; Frost, 1970) have added to these doubts.

This study, by using accurate measuring techniques, establishes beyond doubt that a fall in blood pressure occurs after the introduction of cement into the proximal end of the femur but rarely after acetabular implantation. The magnitude and time relations of this fall have been noted, and possible causes are discussed.

Method

Of 22 consecutive cases studied 18 underwent total hip replacement with the McKee-Farrar prosthesis and 4 had subcapital fractures of the femoral neck. Two of the latter had Thompson prostheses fixed with cement, and two received an Austin Moore prosthesis without cement. The average age of the patients was 63 years.

Patients up to the age of 60 were premedicated with papaveretum 20 mg and hyoscine 0·4 mg intramuscularly. Above this age they received pethidine and atropine. A "sleep dose" of not more than 300 mg of intravenous thiopentone was followed by 75 mg of intravenous suxamethonium. A cuffed endotracheal tube was passed. Anaesthesia was maintained by 70% nitrous oxide and 30% oxygen, together with minimal halothane, and the patients were allowed to breathe spontaneously. All patients received isotonic saline intravenously during the operation. Blood loss was estimated by swab weighing and replaced accordingly.

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The radial artery on the non-dependent side was cannulated with a 20 S.W.G. Medicut cannula (Brunswick Corporation). A central venous pressure line was established through an antecubital vein, using a Drum-Cartridge catheter, 14 gauge (Abbott). Arterial and central venous pressures together with the E.C.G., standard lead II, were recorded on a Mingograph EL34 (Elema-Schonander Ltd). Samples of arterial blood were estimated for pH, P_{CO_2}, and P_{O_2} on a Radiometer PHM27 blood gas analyser.

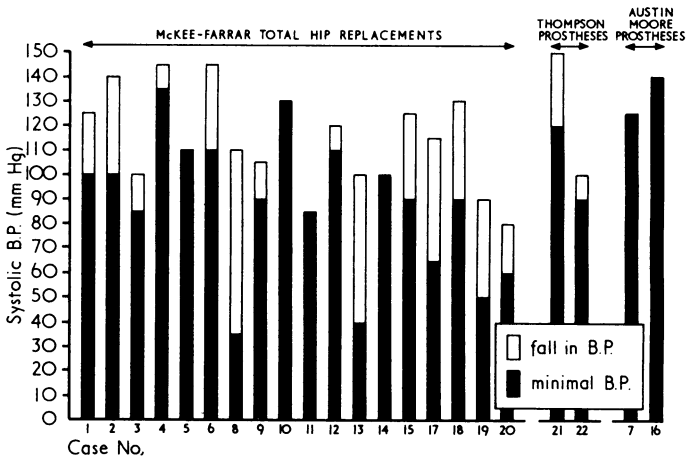
With the exception of one patient (Case 4), who had an anterolateral exposure of the hip joint, all hips were exposed through a posterolateral approach. The acetabulum and upper femoral shaft were prepared in the usual way. Before packing the femoral medullary cavity a polyethylene cannula was introduced to act as a vent in all but three patients.

The acrylic cement used was supplied by North Hill Plastics Ltd. and marketed as Surgical Simplex—P.

Results

Blood Pressure Change after Acetabular Implantation of Acrylic Cement.—In 15 out of the 18 patients who received an acetabular implantation of acrylic there was no change in systemic arterial blood pressure. Cases 9 and 14 showed small falls in systolic arterial blood pressure. Case 13 showed a rise in pressure of 50 mm Hg. These changes occurred within 90 seconds of insertion of cement into the acetabulum.

Blood Pressure Change after Implantation of Acrylic Cement into the Proximal Femoral Shaft.—In 16 out of the 20 patients who received femoral shaft acrylic systolic arterial blood pressure fell by 10 mm of mercury or more (see Chart). The average fall in systolic blood pressure was 32 mm Hg. The maximal fall in systolic blood pressure was 75 mm, and four patients showed no change. The fall in systolic pressure was always accompanied by a fall in both diastolic and pulse pressures. The two patients who received Austin Moore prostheses without cement showed no change in blood pressure at the time of insertion of the prosthesis. Hypotension occurred between 12 and 90 seconds after introducing the cement into the femur. The average time of onset was 41 seconds. The



Fall in systolic arterial blood pressure before and after acrylic implantation.

onset of hypotension always preceded impaction of the prosthesis and reduction of the components. The period of hypotension lasted between 20 and 409 seconds.

Myocardial Changes with Implantation of Acrylic.—No significant E.C.G. abnormalities were recorded either at the time of acrylic implantation or during any subsequent period of hypotension. A tachycardia was noted at the time of hypotension in five cases.

Central Venous Pressure.—There was no change in central venous pressure corresponding with the hypotensive episodes.

Blood Gas and Acid/Base Changes.—In 11 patients arterial blood gas analysis was carried out before and during the period of hypotension. There has been no evidence of significant oxygen desaturation or alteration of $Paco_2$ or pH at the time of hypotension.

Case Report

A 79-year-old woman who weighed 16 stone (92·5 kg) died. She sustained a subcapital fracture of the right femoral neck which was nailed within 48 hours of injury. She developed atrial fibrillation and cardiac failure after the operation and was treated with digoxin 0·25 mg daily and frusemide 40 mg each morning. Two weeks after the initial operation she underwent further surgery for the insertion of a Thompson femoral head prosthesis because the Smith-Petersen nail had cut out of the femoral head. Twenty-two seconds after inserting acrylic cement into the proximal femoral shaft a 10-mm drop in systolic blood pressure occurred, lasting for 30 seconds. The blood pressure returned to the previous level. Four minutes and 42 seconds after the insertion of cement a further more profound fall in blood pressure to 25 mm Hg occurred. Cardiac arrest occurred 25 minutes after insertion of acrylic cement. External cardiac massage was begun, but resuscitation was unsuccessful.

At necropsy there was a massive antemortem thrombus occluding the right pulmonary artery. Histological examination of the lungs, kidneys, and brain showed the presence of extensive fat and marrow emboli.

Discussion

We have shown that there is often but not invariably a fall in systemic arterial blood pressure after implantation of acrylic bone cement into the proximal femoral shaft during prosthetic replacement of the femoral head. Insertion of cement into the acetabulum is rarely accompanied by such a fall. The reason for this difference is not apparent from the investigation.

In this series of patients neither age, nor a history of cardiovascular disease, nor pre-existing blood pressure seemed to influence the fall of arterial blood pressure during implantation. The cement was ready for insertion at times which varied from two and a half to four minutes from the beginning of mixing. Within these time limits there was no relationship with the degree of fall in arterial pressure. Two out of three patients without a femoral vent showed a fall in arterial pressure after implantation of acrylic cement.

The observed hypotension could be explained by the toxic effect of methylmethacrylate monomer or additives such as dimethylparatoluidine absorbed into the circulation. Homsy (1969) demonstrated monomer absorption in dogs and in six patients undergoing hip arthroplasty using ^{14}C-labelled monomer. The time of onset of hypotension in our patients would appear to correspond with the time of maximum concentration of monomer in his patients. The apparently minor effect of acetabular acrylic on blood pressure is difficult to explain on this basis. Possibly the surface area for absorption and the vascularity of the acetabulum are less than those of the femur, and the pressure developed at impaction is lower.

Any procedure which raises the intramedullary pressure such as replacing the femoral head may force fat and marrow into the venous circulation. The pressure developed in the presence of the prosthesis and cement may be very high indeed. As a cause of the observed hypotension fat embolism is a possibility. However, the hypotensive effect begins and is well advanced before impaction of the prosthesis, and careful monitoring of the arterial Po_2 has failed to show significant oxygen desaturation, which is frequent in fat embolism (Ross, 1970). We have not observed any of the clinical features of the fat embolism syndrome in our patients during or after operation.

The rise in intramedullary pressure which must follow the introduction of cement and prosthesis into the femoral cavity may stimulate receptors within the medullary canal and so initiate a reflex fall in systemic blood pressure similar to the carotid sinus reflex, but we have never observed any accompanying bradycardia. Other possible factors in the production of hypotension such as the effect of cement temperature, air embolism, and sensitivity to acrylic warrant investigation.

The cause of death in Case 22 was certainly the massive thrombotic pulmonary embolus found at necropsy. Massive fat embolism may have been a contributory factor (Gresham *et al.*, 1971). The possibility of external cardiac massage itself giving rise to pulmonary fat and marrow embolism cannot be ignored (Jackson and Greendyke, 1965). Fractures of the ribs and sternum during external cardiac massage in this age group are common. It is noteworthy that there was a transient fall in arterial blood pressure shortly after implanting cement, which returned to normal before the terminal cardiovascular collapse.

A prospective study is being undertaken to measure changes in intrafemoral pressure, blood monomer, and blood fat levels during hip arthroplasty.

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