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Changes in Arterial Oxygen Tension during Total Hip Replacement

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Several cardiac arrests during total hip replacement in man have been reported.[1-5] Most of these catastrophies have occurred a few minutes after the application of acrylic bone cement to bone, particularly the femoral shaft. Possible causes of the arrests include diffuse pulmonary emboli of fat, other bone marrow elements, air or methylmethacrylate polymer, hypotension from sudden monomer-induced peripheral vasodilatation, and anaphylactic shock.[2,5] The report of a slight decrease in Pa_{O_2} 2 minutes after the application of acrylic bone cement to the femoral shaft in man[6] prompted us to monitor the changes in Pa_{O_2} during total hip replacement.

MATERIALS AND METHODS

Six male patients, ASA Class I or II, undergoing total hip replacement, were chosen at random. Of the six patients, two were being operated on for the second time. Premedication consisted of atropine, 0.4 mg, and either one or a combination of pentobarbital 50–100 mg, diazepam, 5–10 mg, and morphine sulfate, 5–15 mg administered intramuscularly about an hour before operation. Anesthesia was induced with sodium thiopental and endotracheal intubation was accomplished with the aid of succinylcholine. Three patients received halothane N_2O–O_2 and three, morphine–N_2O–O_2–*d*-tubocurarine. Flow rates of N_2O and O_2 were kept constant throughout the procedure. Respiration was controlled with an Air-Shields ventilator at a tidal volume of 10–12 ml/kg and a rate of 10–12/min.

With the patient in the lateral position, a no. 16 catheter was inserted percutaneously into a radial artery and an arterial blood sample was taken and analyzed for *p*H, P_{CO_2} and P_{O_2} using an Instrumentation Laboratories gas analyzer. A catheter with an oxygen electrode at the tip was inserted through the arterial catheter, kept in place for more than 30 minutes for *in-vitro* equilibration with the blood, and then calibrated with the oxygen tension obtained at the time of percutaneous puncture. A Multi-purpose Differential Oxygen Analyzer (International Biophysics Corporation) was used for continuous monitoring of arterial oxygen tension.

After the establishment of a clinically steady anesthetic level and a stable cardiovascular state, with careful blood transfusion to replace measured loss, the surgeon applied the acrylic bone cement to the bone.

Specific recordings of blood pressure (Riva Rocci) and pulse rate were made just before, at 30-second intervals for 5 minutes, and thereafter every minute for another 10 minutes

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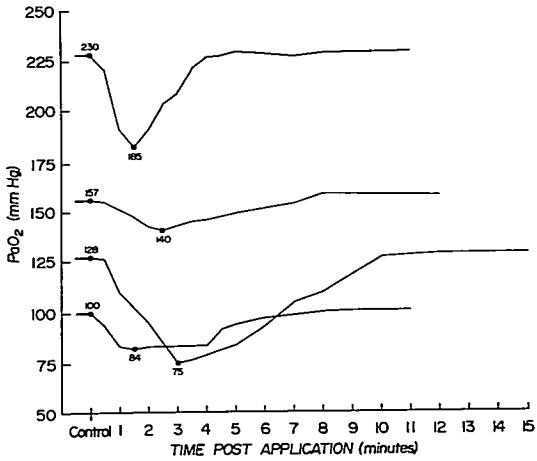

FIG. 1. Pa_{O_2} changes after application of acrylic bone cement to the femoral shaft in four patients operated on for the first time. Inspiratory oxygen concentrations ranged from 30 to 50 per cent.

after the application of the bone cement. Pa_{O_2} was monitored continuously.

The values for Pa_{O_2} obtained by the indwelling oxygen electrode were compared in one patient with arterial blood samples drawn from a no. 22 scalp-vein needle inserted into the other radial artery 1, 3, and 5 minutes after application of acrylic bone cement.¶

RESULTS

Mean control *p*H, Pa_{CO_2} and Pa_{O_2} were 7.53, 30.7 mm Hg, and 143.1 mm Hg, respectively.

None of the four patients operated on for the first time had any change in Pa_{O_2} following the application of acrylic bone cement to the acetabulum. However, when acrylic bone cement was inserted into the femoral shaft, Pa_{O_2} values of all four patients decreased in less than 30 seconds, reaching an average decrease of 33 mm Hg (16–53 mm Hg) in 3 minutes. Pa_{O_2} gradually returned to control levels in an average of 8 minutes (5–12 minutes).

During this time, mean systolic blood pressure decreased from 106 (90–122) to 99 (80–115) mm Hg and diastolic pressure from 79 (70–95) to 76 (65–85) mm Hg at 1 minute (0.5–2.0 minutes) without any significant change in pulse rate. These changes in blood pressure were not statistically significant.

Two patients operated on for a second time had decreases in Pa_{O_2} of 5 and 35 mm Hg, respectively, after the application of acrylic bone cement to the acetabulum. Only one of these patients had a decrease in Pa_{O_2} (18 mm Hg) at the time of insertion of acrylic bone cement into the femoral shaft. These findings are different from those in patients who had the operation for the first time. The acrylic bone cement was applied 3 to 4 minutes after mixing.

DISCUSSION

Our study showed a sudden, sharp, transient decrease in Pa_{O_2} following an application of acrylic bone cement to the bone during total hip replacement. The greatest decrease in Pa_{O_2}, from 128 to 75 mm Hg (fig. 1), occurred

¶ Acrylic bone cement is a mixture of polymethyl methacrylate styrene copolymer and barium sulfate, U.S.P., 40 g, and methylmethacrylate (monomer) 20 ml.

without any change in blood pressure or pulse rate. The physiopathologic mechanisms for the changes in Pa_{O_2} are unknown. The transience of the Pa_{O_2} change, with complete recovery to the control value in the 8 minutes with minimum changes in blood pressure, make pulmonary emboli of any origin an unlikely cause.

It can be easily postulated in this study that the decrease in Pa_{O_2} was directly related to the amount of acrylic polymer absorbed into the systemic circulation through the bone. In patients operated on for a second time, it was much easier to remove old bone cement from the acetabulum than from the femoral shaft, causing the acetabulum to be more vascular and more absorbent. Consequently, when acrylic bone cement was applied in the bone for the repeat total hip replacement, the decrease in Pa_{O_2} was greater following its insertion into the acetabulum than into the femoral shaft.

It is impossible to exclude the effects of cardiac output on Pa_{O_2} changes[7] because neither cardiac output nor central venous oxygen concentrations were measured. However, no evidence of a direct relationship between decreases in blood pressure and Pa_{O_2} in our study makes us postulate that this change in Pa_{O_2} was the result of a sudden and transient change in the pulmonary vasculature produced by the acrylic bone cement.

Until further investigations defining the exact cause of the Pa_{O_2} change are performed, we suggest that patients undergoing total hip replacement be given enough oxygen to maintain Pa_{O_2} at twice the normal values for a few minutes before and after the application of acrylic bone cement in the bone.

Summary

The changes in arterial oxygen tension following application of acrylic bone cement in the bone were studied in six patients undergoing total hip replacement, four of whom were having the operation for the first time and two for the second time.

In patients operated on for the first time, a sudden and transient decrease in Pa_{O_2}, averaging 32.7 mm Hg (16–53 mm Hg) was noted only with application of the bone cement to the femoral shaft, whereas in two patients who had the operation for the second time changes in Pa_{O_2} were greater with application of the bone cement to the acetabulum. The decrease in Pa_{O_2} seems to be related to the amount of acrylic polymer absorbed into the systemic circulation through the bone. The changes in Pa_{O_2} occurred independent of changes in blood pressure.

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