Percutaneous catheterisation of the radial artery in newborn babies using transillumination

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SUMMARY A technique for inserting radial artery catheters percutaneously in newborn babies using transillumination is described. Catheterisation was successful in 69% of the 107 babies in whom it was attempted. In the last 30 attempts there was an 85% success rate with an average useful life of 100 hours. The average weight of these babies was 1405 g, with a range of 620-4250 g. The method has several advantages over previous methods.

A rapid, simple, and safe method of cannulating the radial artery percutaneously in newborn babies is described. Early results with this technique have been reported previously (Pearse, 1977).

Apparatus

A rubber oxygen funnel cut down to a diameter of 2 cm (Fig. 1) is attached to the end of a fiberoptic bundle, connected to a variable intensity, cold light source (American Cystoscope Makers Inc., ACMI 95A). This apparatus is also used for transilluminating the skull and for the rapid detection of pneumothoraces (Kuhns *et al.*, 1975).

Fig. 1 Diagrammatic representation of the distal end of the fiberoptic bundle.

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The catheter is an Abbocath 22G, made of soft Teflon mounted on the outside of a hollow metal stylet. The stylet is fixed to a clear plastic chamber which has a filter permeable only to air at the opposite end, so that blood is able to flow back up the stylet and into, but not out of, the chamber. After successful insertion, the catheter is attached to a piece of clear plastic extension tubing 7 cm long (volume 0.2 ml) with an inbuilt 3-way stopcock (Viggo 4041-0).

Method

The forearm of the baby is held, ventral surface uppermost, between the index and middle fingers of the operator's left hand (Fig. 2). The baby's hand is held slightly dorsiflexed by the operator's thumb (over-extension of the hand causes reduced flow

Fig. 2 Position of the operator's left hand, holding the baby's right arm and the transillumination funnel.

through the radial artery and makes the procedure more difficult). The rubber funnel is held between the middle and ring fingers against the dorsal surface of the baby's wrist. From the ventral side it is possible to see the radial and ulnar arteries in the lower forearm and wrist, as dark lines against a bright, transilluminated, background (Fig. 3). It is not usually necessary to darken the room to see these quite clearly. The arteries may be differentiated from the veins in this region because the latter move with the skin, whereas the arteries are fixed.

After identifying the two arteries, the wrist is held firmly on the radial side and the blood squeezed out of the hand. If the colour returns rapidly to the hand while pressure is maintained over the radial artery it is safe to assume that the collateral circulation in the hand is sufficient (Allen, 1929) and that the catheterisation may proceed.

The wrist is cleaned with an iodine/alcohol solution and this is washed off with chlorhexidine in alcohol and allowed to dry. Holding the funnel beneath the wrist in the manner described, an Abbocath is advanced slowly, under direct vision, in the direction of the radial artery at an angle of about 20° until blood can be seen in the clear plastic chamber. The Abbocath is then advanced a further half mm (to bring the tip of the Teflon catheter into the arterial lumen) and then, while advancing the Teflon catheter slightly with thumb and index finger,

the stylet is slightly withdrawn using the middle finger against the palm. The Teflon catheter can now be pushed with ease up the artery and the stylet completely withdrawn, placing the index finger of the left hand over the radial artery, just proximal to the tip of the catheter, to prevent blood loss.

The catheter is now attached to the extension tubing, which has been previously filled with saline containing 5 units heparin/ml. Blood is allowed to run back into the plastic tubing and the system is checked for air bubbles. The catheter is flushed with the heparin solution and the tap turned off towards the patient. The catheter is fixed to the skin using a narrow piece of sticking plaster (approximately 3 mm wide) placed adhesive side uppermost under the catheter and then crossed over the catheter and stuck to the skin of the forearm to form a V-shape, with the point of entry of the catheter in the skin at the apex of the 'V'. The entry point is sprayed with a plastic spray (for example Nobecutane). The arm is splinted and the hand fixed to the splint so that the fingers and thumb can be clearly seen (Fig. 4). Rubber stoppers (Braun, 23751) are attached to the side holes of the 3-way stopcock and samples are withdrawn by piercing these with a 23 G needle attached to a 1 ml syringe, preferably a glass one. All connections in the system are made by Luer locks to lessen the risk of accidental detachment and subsequent haemorrhage.

Fig. 3 Radial and ulnar arteries as seen by transillumination of the wrist. Their outline is blurred because they lie deep and the light is dispersed by the overlying tissues.

Fig. 4 Method of fixation of the catheter and of splinting the arm.

Results

Radial artery catheterisation was attempted in 107 babies. In 74 (69%) of these it was successful, and their average weight was 1466 g (range 620 to 4250 g). (There was an 85% success rate in the last 30 attempts as the five neonatologists become more adept at the technique. The average weight of these babies was 1405 g.)

The catheters so placed had an average useful life of 70 hours, with a range of 10 to 240 hours. The majority (69%) were removed because it was no longer possible to obtain a sample through them. Why this was so is not clear as it was generally still possible to obtain the typical arterial blanching pattern of the skin on flushing the catheter. Presumably this is because there is a clot just proximal to the catheter tip which acts as a ball valve, or because of arterial spasm. No catheter contained a clot when it was removed. In 7% of cases the catheter had to be removed because blood was leaking from around the catheter. In 18 (24%) of cases the catheter was removed because it was no longer necessary, either because the condition of the baby had improved so it was no longer necessary to monitor blood gases (12 (16%) babies) or because the baby had died (6 (8%) babies).

All catheter tips were cultured after removal. In two cases *Staphylococcus epidermidis* was grown, but in neither baby was this associated with overt clinical disease. The remaining 72 cultures were sterile. A pustule developed on the ventral surface of the wrist of one baby 10 days after the removal of the catheter. It appeared from its location to be more probably related to an intravenous infusion, inserted some days after the removal of the catheter, and removed 3 days previously. *Staphylococcus aureus* (coagulase positive) was cultured from the lesion.

Complications have been slight. In 5 babies, ecchymoses developed in the skin of the anterior aspect of the forearm. These all occurred early in the series and may have been associated with over-enthusiastic flushing of the catheter. In 2 babies, each with systolic blood pressure below 25 mmHg, the circulation in the hand gave cause for concern shortly after the catheter had been inserted, but within 2 minutes the circulation had improved spontaneously without the catheter being removed. One baby developed a white thumb 20 hours after insertion of the catheter. The catheter was removed and the circulation in the hand rapidly returned to normal. This was thought to be due to spasm caused by prolonged manipulation in an attempt to obtain a sample.

Radial artery catheters have been in regular use in this unit since August 1976, and as yet, no long-term complications have been seen. Follow-up of these babies is planned, with particular reference to subsequent growth and function of the forearm and hand and to the return of the pulse in the radial artery.

Discussion

Monitoring of PO_2 in arterial blood is an essential part of the management of the seriously ill newborn baby. Traditionally this has meant sampling blood from the abdominal aorta via an umbilical artery catheter, which has great disadvantages. It is becoming increasingly apparent that this procedure has a fairly high rate of complications, particularly with regard to infection and thromboembolism. Krauss *et al.* (1970) reported a contamination rate of 55% for umbilical arterial catheters. Thrombosis, with or without embolism, occurs in up to 95%, regardless of the duration of catheterisation according to Neal *et al.* (1972). Most authors quote rates of between 8.8 and 59% (21% Cochran *et al.*, 1968; 12% Wigger *et al.*, 1970; 8.8% Egan and Eitzman, 1971; 23% Tooley, 1972; 59% Tyson *et al.*, 1976). More unusual complications include paraplegia (Krishnamoorthy *et al.*, 1976), intestinal perforation (Hoekstra *et al.*, 1977), septic osteoarthritis (Knudsen and Petersen, 1977), false aortic aneurysm (Malloy and Nichols, 1977), and in the long term, hypertension (Plumer *et al.*, 1976). The sample obtained by this route may also be a poor reflection of the blood going to the brain and retina because of right-to-left shunting through the ductus arteriosus (Roberton and Dahlenburg, 1969). Nor is it possible to insert an umbilical artery catheter after the first few days of life.

In the search for better sites from which to sample arterial blood, most authors have concentrated on the superficial temporal and radial arteries. Early experience with multiple puncture techniques in these arteries has been reported by Thomsen (1964), Bucci *et al.* (1966), Shaw (1968), and Wunderlich and Reynolds (1972). There is general agreement that haematoma formation at the puncture site is a common complication. While this is not a great problem in the case of the temporal artery, because a relatively long segment of the artery is available for puncture, the radial artery is available for puncture only over a short distance. Haematoma formation makes subsequent puncture considerably more difficult. A further argument against multiple puncture techniques is that the sample obtained is probably a poor indication of the situation pertaining before the procedure was begun, particularly if

difficulty was experienced in obtaining the sample (Dangman *et al.*, 1976).

Access to the temporal artery is moderately easy during ventilator therapy, but it is more difficult to obtain a meaningful sample while the baby is breathing spontaneously in an oxygen-enriched atmosphere. These problems are largely overcome by the use of indwelling catheters in the temporal artery (McGovern and Baker, 1968; Gauderer and Holgersen, 1974). However this requires a surgical cutdown procedure on the artery, with or without arterial section, and involves the child in much handling. Excellent results have been described by Au-Yeung *et al.* (1977) of percutaneous catheterisation of the temporal arteries but it is difficult in the first 24 hours of life because of scalp oedema.

A surgical cutdown procedure has also been used for the placement of radial artery catheters (Bartlett and Munster, 1968; Roberton and Dahlenburg, 1969; N. R. C. Roberton, personal communication, 1977) with its attendant risks of vessel loss and infection plus the harmful effects of prolonged handling on the baby. Percutaneous radial artery catheterisation avoids these problems. In a series of 20 patients reported by Adams and Rudolph (1975) only one failure occurred: however the mean weight of this group was 2.534 g and the smallest weighed 1418 g. In the series of 72 neonates described by Todres *et al.* (1975), percutaneous cannulation was successful in 73%: the average weight of these babies was not given but the range was 1100 to 4000 g. Neither article reported any major complications other than haematoma formation. If the right radial artery is catheterised, then the sample obtained is preductal and can be removed without disturbing the baby. If a Gairdner box (Warley and Gairdner, 1962) is being used to administer extra oxygen, then the sample can be withdrawn without altering the concentration of oxygen in the inspired air. Transillumination makes radial artery catheterisation a rapid and simple procedure even on the smallest babies, which in practised hands can be completed within two minutes, thus shortening the time taken while handling the baby and lessening the subsequent fall in arterial PO_2 .

No continuous infusion was used to keep these catheters open because it was felt inadvisable to use any fluid other than 0.9% saline (Enger *et al.*, 1976) and the sodium load of a continuous infusion was considered to be too great, particularly for the smaller babies. In adults, percutaneous radial artery catheterisation has been found to be safe and reliable (Brown *et al.*, 1969; Gardner *et al.*, 1974), although cerebral embolism secondary to flushing of these catheters (Lowenstein *et al.*, 1971), and necrosis of the skin of the forearm (Wyatt *et al.*, 1974) have been described.

These complications can probably be avoided by careful attention to quantity and speed of flushing. In spite of a high incidence of temporary radial artery thrombosis, necrosis of fingers or thumb appears to be rare (Downs *et al.*, 1973; Bedford and Wollman, 1973) and can probably be prevented by first identifying the ulnar artery using transillumination, as it is said to be deficient in 6% to 12% of patients (Hollinshead, 1958, cited by Adams and Rudolph, 1975), and by careful performance of the Allen test (Allen, 1929). In contrast to the experience in adults, no major or irreversible complication has been seen in these babies.

The useful life of radial artery catheters has become progressively longer in this hospital. If the number of patients is divided chronologically into four approximately equal groups, the useful life of the catheter has been 38, 59, 89, and 100 hours. This can partly be explained by improvements in the method. The size of the catheter has been reduced. The original catheter used was an Abbocath 20G which, because of its size, probably caused overdistension of the radial artery, particularly in the smaller babies, with intimal damage and subsequent thrombotic problems, although these were not seen clinically. Early in the series, a 3-way stopcock was attached directly to the end of the catheter. Removal of a sample inevitably caused movement of the catheter in the artery and further intimal damage and arterial spasm. Experience has also emphasised the importance of beginning withdrawal of the sample *slowly* to avoid sucking the wall of the artery on to the catheter tip; this often results in arterial spasm and failure to obtain a sample.

Once the flow has started, surprisingly high rates can be obtained (up to 10 ml minute) and two babies have each received two exchange transfusions, withdrawing blood from the radial artery and injecting blood through an Abbocath in a peripheral vein. Radial artery catheters have also been used successfully to monitor the blood pressure continuously in some of these babies.

Percutaneous radial artery catheterisation is therefore a fairly easy technique using transillumination. Catheters so inserted can perform most of the functions demanded of an umbilical arterial catheter and have several advantages over other methods of obtaining arterial blood in sick babies.

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Note added in proof: Since submitting this paper we have successfully catheterised the radial artery in a further 76 babies. There have been no complications.