Briefly Legal: Loss of Hand Secondary to a Percutaneous Arterial Line

Maureen E. Sims, M.D., Barry Schifrin, M.D,

Features of the Case

Identical, concordant female twins were delivered at 24 4/7 weeks gestation to a 33-year-old G8P4 woman who ruptured membranes ten days prior to going into preterm labor. A full course of antenatal steroids and antibiotics had been administered before the delivery. Twin A had Apgar scores of 4^{1}, $5^{5,}$ and $6^{10,}$ and twin B had Apgar scores of 3^{1}, $4^{5,}$ and 6^{10}. The twins had normal physical examinations, and both were placed on conventional ventilators with low settings, each having received one dose of surfactant. Twin A was transferred to a hospital with a higher level of care on day seven because of constipation. She remained stable, was discharged when full feeds were achieved and has developed normally.

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Twin B, weighing 689-grams, had remained at the birthing hospital. She developed a hemodynamically significant patent ductus arteriosus (PDA) at 48 hours, for which she received one course of indomethacin. A percutaneous central catheter was placed on day 10 to supplement her enteral nutrition.

She remained stable until day **26** when she developed multiple episodes of desaturation associated with a weight gain of 105-grams in the preceding 24-hours. She was placed NPO and observed. The next day, she required increasing inspired oxygen and was placed on the high-frequency oscillatory ventilator. After the Allen Test was passed, several attempts to place a percutaneous arterial catheter (PAL) were made. ***There was no description of the number of punctures or the side on which the attempts were made.*** A complete blood count (CBC) showed a hematocrit (hct) of 28%, a white blood count (WBC) of 5 u/L, a platelet count of 204 u/L, and a chest radiograph showed diffuse haziness. With a presumptive diagnosis of sepsis, blood cultures were drawn, and the baby was started on vancomycin, cefotaxime, and gentamicin. Her abdominal girth was increasing. Her blood gases showed a mixed acidosis with pHs ranging from 7.03-7.13. Her diastolic blood pressures (BP) were in the teens, and her heart rate was persistently >200 bpm. She was given two transfusions of packed red blood cells and multiple boluses of normal saline as well as increasing dosages of dopamine and eventually epinephrine in an effort to stabilize her BP. No echocardiogram was obtained. Later in the night, a PAL was successfully placed in the right radial artery to monitor BPs and sample blood gases continually. There was no documentation of the Allen Test being performed. The waveform was normal. Her abdominal girth continued to increase.

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In the early morning on day 28, the PAL waveform appeared normal. The right upper extremity was noted to be pink, mottled, warm, and to have a capillary refill <3 seconds, but no comment was forthcoming about the hand. ***However, there was a checkmark in the hospital form signifying that the right had was "mottled" but lacked any further description, and the physician was not notified about the mottling.*** For the following 6 hours, there was no further documentation of either the PAL waveform or the appearance of the hand. In the deposition, ***the night nurse explained that she did not document the findings but was sure she had evaluated them as per her usual practice – and assumes that she had found them normal.*** In the morning, 9 hours after the PAL was placed, the oncoming nurse noted that the arterial waveform was dampened and that the right extremity was pink, mottled, and cool - but she did not notify the physician. ***The nurse stated in her deposition that she knew these findings were abnormal but did not report them to the neonatologist because she was very busy with this critically ill baby. She could not remember if the whole right extremity was mottled and cool or just the right hand.*** **Both night and the morning nurses affirmed that whenever a PAL was in place, the nursing policy was to check the waveform, evaluate the hand hourly, and report any abnormal findings to the physician immediately.** Within an hour, the hand became white. At this point, the nurse informed the neonatologist about the earlier dampened waveform and the cool, pale hand and added that the waveform was now flat. Neither BPs nor blood draws had been possible from the PAL for several hours prior to the morning shift. ***In his deposition, the treating neonatologist stated that he ordered the nurse to flush the catheter, loosen the dressing, and apply a warm compress. The plaintiff neonatologist agreed that loosening the tape was potentially helpful, and repositioning the hand was sometimes effective, but warming the hand, however, was contraindicated.***

Further, any attempts at aspiration to draw out clots could be useful, but irrigation should be extremely gentle lest forceful entry release clots, obstruct flow, and compromise the hand even further. Other maneuvers, including elevating the right arm, applying warm compresses to the opposite (left) arm to

attempt reflex vasodilatation, and trying nitroglycerin, have a varying success rate but have little risk. Most critically, since the purpose of the PAL was for blood sampling and BP monitoring, neither of which had been possible for several hours, the PAL should have been removed hours earlier when it stopped functioning. When evidence of a pale, cold hand became present, the PAL should have been discontinued immediately.

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As the various maneuvers failed to re-establish circulation in the hand, the nurse contacted the neonatologist on several occasions. In each instance, ***the neonatologist directed the nurse to continue to observe. The plaintiff neonatologist contended that had the proper assessments been performed before the morning nurse arrived, the PAL would have been removed when the waveform was damped if positioning or readjusting the tape did not improve it. Mottling of the hand made it more urgent; a cool, white hand demanded immediate removal.***

Two and a half hours after the morning nurse assumed care of the baby, the neonatologist ordered the PAL to be removed. As a curious aside, ***in her deposition, the mother related that about 2 months after the incident, an unknown individual had sent her a letter stating that the neonatologist was being adamant about leaving the PAL despite multiple nursing requests to have it removed. The post-marked, handwritten, but unsigned letter was produced at her deposition.***

The baby was transferred to a center with a higher level of care because of her abdominal distension. She was hypotensive, tachycardic, massively edematous, had a tense distended abdomen and a pulseless white hand. Her chest radiograph showed white-out, and her abdominal radiograph showed a homogeneously opacified abdomen with air present only in the stomach. She had an exploratory laparotomy for presumed perforation secondary to necrotizing enterocolitis, but the intraperitoneal contents were normal except for massive ascites. Her cardiac ultrasound showed a huge PDA, which was ligated soon after the abdominal surgery. All blood cultures were negative. The thinking of the physicians at the receiving hospital was that the hypotension at the referral hospital was secondary to the PDA; subsequently, the baby developed heart failure as the attempt was made to normalize her BP with multiple fluid boluses. The massive volumes of fluid to increase her blood pressure additionally compressed her inferior vena cava as increasing ascites developed, thereby limiting venous return to the heart. Her right hand was amputated at a month of age. ***The plaintiff neonatologist agreed and pointed that this further underscored the need for the cardiac ultrasound to evaluate the PDA at the birthing hospital.***

The birthing hospital and the neonatologist were sued. **The plaintiffs alleged: 1) that the nurses failed to assess hourly the color, perfusion, and temperature of the hand and the waveform of the PAL as required by their own standards. 2) the nurses failed to notify the physician timely about the abnormal findings and failed to summon the physician. Further, the plaintiffs alleged that the physician failed to timely remove the PAL when the hand was cold and pale. When the physician did not order the PAL to be removed immediately, the nurses needed to advocate for the baby by going up the chain of command by first discussing the issue with the neonatologist, and if that failed, then informing the supervising nurse could be accomplished very quickly, or informing the physician that it was unacceptable to leave the PAL in place under the circumstances. As a last resort, the nurse should have discontinued the PAL and then explained why it was necessary to her supervisors and the physician who was resisting.**

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The case was settled before trial.

Discussion

For over 40 years, peripheral arterial catheter insertion has been indispensable in newborn intensive care despite the risk of both short- and long-term complications. Complications include thromboembolism, vasospasm, infection, iatrogenic blood loss, peripheral nerve damage, rarely pseudoaneurysm, and arteriovenous fistula. The overall risk of ischemic injury secondary to radial or ulnar artery catheterization is approximately 5%. Precautions during the insertion, vigilance in the maintenance of catheters, removal as soon as medically feasible, and prompt discontinuation when signs of compromise develop reduce the risk of complications. The radial and posterior tibial arteries are the primary sites for cannulation. Because of the potential risk of ischemic injury to the entire hand or arm, the ulnar, brachial, and axillary arteries generally are used for cannulation only if arterial access at the primary site is unsuccessful.

Monitoring the extremities frequently, especially the tips of the fingers or toes, for signs of vascular compromise is crucial. Studies of Doppler flow of radial artery by Hack et al. showed complete occlusion in 63% of infants with radial artery catheterization. Further, blood flow to the site distal to the cannulation site depended on adequate collateral circulation. Blood flow in the radial artery did resume within 1-29 days after catheter removal.

The Allen Test is routinely used to demonstrate collateral circulation in the catheterized extremity. Although inter-observer variability exists with the Allen test, it is routinely used to demonstrate

collateral circulation.

Evaluation of the waveform is useful in determining how well the PAL is functioning (Figure). Flattening of the curve can be caused by obstruction of the catheter from clot formation, or from the catheter being pushed against the arterial wall, or from bent tubing. If an obstruction is suspected, the catheter should be gently aspirated. If no resistance is encountered and the catheter allows sampling, a 1 ml flush may be given.

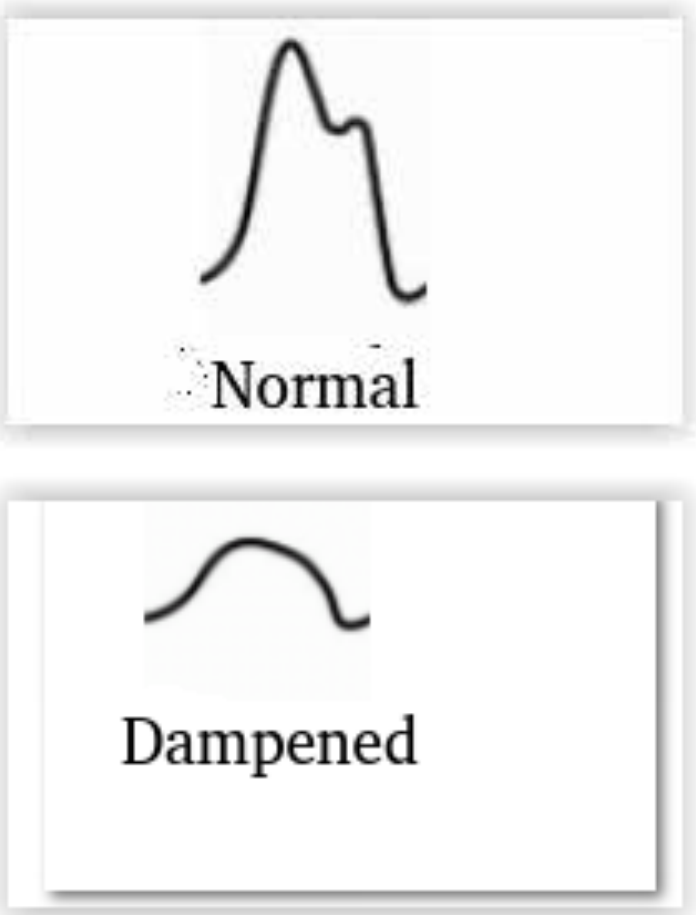

Figure – Arterial waveform from PAL catheter illustrating:
A. *Normal arterial waveform*
B. *Dampened arterial waveform*

Although there are multiple case reports of ischemic injury with peripherally inserted arterial catheters, very limited data is available on their use in extremely low birth weight infants. When peripheral ischemia is recognized immediately, and appropriate action is taken, permanent loss of digits is generally avoided. Topical nitroglycerin has been found to be effective in restoring perfusion in a few cases in which radial artery catheterization resulted in compromised hands. As stated, immediate removal of the catheter at the earliest signs of ischemia is essential to prevent ensuing tissue loss.

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Corresponding Author:

Maureen E. Sims, M.D.
Professor of Pediatrics
University of California, Los Angeles
Los Angeles, CA
email: mes@g.ucla.edu

Barry Schifrin, M.D,
Formerly Professor of Obstetrics and Gynecology
Western University
Pomona, CA