lingual nitroglycerin can be attributed to: 1) vasodilation in poorly ventilated areas of the lung; 2) a relative increase in perfusion through the dependent less ventilated area of the lung due to the fall in pulmonary artery pressure; 3) a decrease in cardiac output; and 4) an increase in intrapulmonary shunt.[8]

Since the cardiac output did not increase after deep breathing, increase in Pa_{O_2} cannot be linked to cardiac output. A small increase in shunt fraction (1.4 per cent) observed in our previous study[9] was not quantitatively sufficient to account for the nitroglycerin-induced decline in arterial Pa_{O_2}. Presumably then, a rise in Pa_{O_2} can be attributed to an improvement of ventilation/perfusion ratio produced by deep breaths.

Improvement in Pa_{O_2} in patients (premedicated, supine, breathing room air) who did not receive nitroglycerin indicates that deep breathing can reverse not only nitroglycerin-induced V/Q abnormalities but also pre-existing ventilation perfusion imbalance.

The clinical significance of the observed changes in Pa_{O_2} after administration of nitroglycerin is not yet clear. However, in critically ill patients with angina pectoris, a decline in available oxygen may offset its beneficial effect. High-inspired oxygen concentrations probably should be used when nitroglycerin is given for the treatment of anginal pain or when narcotics and nitroglycerin are given to patients with severe coronary artery disease.[2] Although the use of oxygen may be convenient under hospital or intensive care conditions, it is not practical for ambulatory patients. The present study suggests that a simple method, such as deep breathing, may be an easy alternative to prevent or treat nitroglycerin-induced hypoxemia.

References

1. Mookherjes S, Fuleihan D, Warner RA, et al: Effects of sublingual nitroglycerin on resting pulmonary gas exchange and hemodynamics in man. Circulation 57:106–110, 1978
2. Kopman EA, Weygandt GR, Bauer S, et al: Arterial hypoxemia following the administration of sublingual nitroglycerin. Am Heart J 96:444–447, 1978
3. Hale CA, Westphal DW: Hypoxemia following the sublingual administration of nitroglycerin. Am J Med 65:911–917, 1978
4. Rowe G: Inequalities of myocardial perfusion in coronary artery disease, "coronary steal". Circulation 42:193–194, 1970
5. Forman R, Kirk ES, Downey JM, et al: Nitroglycerin and heterogeneity of myocardial blood flow: reduced subendocardial blood flow and ventricular contractile force. J Clin Invest 52:905–911, 1973
6. Huntsberger DV, Leaverton PE: Statistical Inference in the Biological Sciences. Boston, Allyn and Bacon, 1970, pp 211–213
7. Guyton AC. Text Book of Medical Physiology. Philadelphia, W. B. Saunders Company, 1976, p 520–521
8. Annest SJ, Rhodes GR, Stratton HH, et al: Increased intrapulmonary shunt following infusion of nitroglycerin or nitroprusside in patients with posttraumatic respiratory distress. Surg Forum 30:22–24, 1979
9. Weygandt GR, Kopman EA, et al: Mechanism of nitroglycerin-induced hypoxemia. Cathet Cardiovasc Diagn 6:387–395, 1980

Anesthesiology
55:76–78, 1981

The Effect of Method of Radial Artery Cannulation on Postcannulation Blood Flow and Thrombus Formation

RONALD M. JONES, M.B., CH.B., F.F.A.R.C.S.,* ANNE B. HILL, M.D.,† MICHAEL L. NAHRWOLD, M.D.,‡ ROY E. BOLLES, B.G.S.§

Percutaneous radial artery cannulation is performed to permit continuous monitoring of systemic arterial blood pressure and to facilitate repeated sampling of arterial blood. The radial artery is chosen because it is accessible, easy to cannulate, and collateral circulation is usually good and easily confirmed. Two methods of cannulation are used: transfixing, in which

* Consultant Anaesthetist, Department of Anaesthetics, the City Hospital, Nottingham, England.

† Assistant Professor, Department of Anesthesiology, the University of Michigan Medical Center.

‡ Associate Professor, Department of Anesthesiology, the University of Michigan Medical Center.

§ Research Associate, the University of Michigan Medical Center.

Received from the Department of Anaesthetics, the City Hospital, Nottingham, England, and the Department of Anesthesiology, the University of Michigan Medical Center, Ann Arbor, Michigan. Accepted for publication December 29, 1980.

The work for this manuscript was done at the University of Michigan Medical Center.

Key words: Monitoring: blood pressure. Arteries: radial. Complications: thrombosis.

the posterior wall of the artery is deliberately punctured; and direct threading, in which the posterior wall is not punctured. We sought to determine whether the method of cannulation influences postcannulation blood flow and thrombus formation.

Materials and Methods

The study was approved by the committee to review grants for clinical research and investigation involving human beings. Verbal informed consent was obtained from forty patients scheduled for open heart surgery. All were seen the day prior to surgery when radial and ulnar artery blood flow were assessed in both wrists, using a Doppler ultrasonic flow meter (Sonicaid® Model BV381), graphical recordings of blood flow velocity being recorded. Any patient with reduced ulnar artery flow as indicated by an attenuated ultrasonic flow recording, was excluded from the study. Additionally, Richard's Modification[1] of Allen's test[2] was performed. If the time to the appearance of a palmar capillary flush was in excess of 5 seconds, the patient was excluded from the study. Cannulation was performed aseptically by one of two anesthesiologists, each well practiced at one particular technique, the method of cannulation being randomized. They both have had over five years of experience and have used this technique innumerable times. Twenty-gauge non-tapered Teflon® catheters (Abbocath) were used and the number of attempts at cannulation noted. Two patients were excluded from the study, when during cannulation by direct threading, the posterior wall of the artery was thought to have been punctured. The skin over the area of the tip of the cannula and in the hand was inspected at least every 12 hours for signs of circulatory insufficiency. Decannulation was performed using proximal and distal pressure and suction to remove any luminal clot,[3] with pressure being maintained at the site of decannulation for five minutes. After decannulation, blood flow was assessed at 1 hour and at 5 days by the investigator who had seen the patient prior to surgery, but who did not know the method of cannulation. Ultrasonic flow meter readings were obtained 1 cm distal to the cannulation site, at the level of cannulation, and 1 and 5 cm proximal to this level. The duration of cannulation and diameter of the wrist measured at the ulnar styloid were recorded. During the postoperative period, all cannulas were flushed using a continuous flushing device (Intraflo®). All patients receiving prosthetic valves, and those receiving porcine valves who were in atrial fibrillation, were fully anticoagulated with Coumadin® to maintain the prothrombin time between 20 and 30 per cent of control. All other patients received 5000 units of heparin, subcutaneously, every 12 hours. Seven patients were fully anticoagulated in each group.

Numerical data were analyzed using Student's t test and classification data analyzed using the chi-square (χ^2) test.

Table 1. Postcannulation Blood Flow

	Transfixed (n = 20)	Direct Threading (n = 20)
1 hour*		
No change	18	17
Reduced flow	2	1
No flow	0	2
5 days†		
No change	20	18
Reduced flow	0	2
No flow	0	0

* $P > 0.05$.
† $P > 0.05$.

Table 2. A Comparison of Variables*

	Transfixed (n = 20)	Direct Threading (n = 20)	P
Duration of cannulation (hr)	60.8 ± 33.1	63.3 ± 24.0	>0.05
Wrist diameter (cm)	16.5 ± 1.2	16.7 ± 1.5	>0.05
Attempts at cannulation	1.4 ± 0.7	1.6 ± 0.9	>0.05

* Values are means ± SD.

Results

There was no significant difference in blood flow between the two groups (table 1) nor were there any serious sequelae or instances of frank ischemia. Only one patient was excluded from the study because palmar capillary flush appeared after 15 seconds when performing an Allen's test.

Wrist circumference, duration of cannulation, and the number of attempts at cannulation were not significantly different in the two groups (table 2). In only one patient was a small (approximately 1 mm × 1 mm) luminal clot aspirated during decannulation. This patient was in the transfixing group and there was no evidence of attenuated blood flow after decannulation.

Discussion

Transfixing is a commonly used method of percutaneous radial artery cannulation. However, if deliberate puncture of the posterior wall of the artery results in a markedly higher incidence of thrombus formation, this technique should not be used routinely.

At the times when blood flow was assessed, our results failed to demonstrate a higher incidence of postcannulation thrombus formation when transfixing

was used as the method of insertion. Blood flow was not assessed until one hour after decannulation in order to minimize the possibility of reduced flow, resulting from vessel spasm, ascribed to thrombus formation. Blood flow was also assessed five days after decannulation. This period of time was chosen because thrombus formation occurring later than five days after decannulation is uncommon and the possibility of recanalization occurring within four days is also uncommon.[4]

The incidence of thrombus formation occurring after cannulation with 20-gauge, non-tapered Teflon® catheters is low. Five days after decannulation the incidence in our study, regardless of the method of cannulation, was 5 per cent. This compares with an 8 per cent incidence of occlusion previously reported by Bedford.[5]

Although we were unable to demonstrate a difference in thrombus formation comparing the two techniques, the low overall incidence of thrombosis means we cannot exclude such a possibility. However, if such a difference does exist, it must be small. We conclude that the commonly practiced technique of transfixing does not carry an appreciable increased risk to the patient.

References

1. Richards RL: Peripheral arterial disease, a physicians approach. Edinburgh and London, E & S Livingstone, 1970, p 47
2. Allen EV: Thromboangiitis obliterans: Methods of diagnosis of chronic occlusive arterial lesions distal to the wrist with illustrative cases. Am J Med Sci 178:237–244, 1929
3. Bedford RF: Removal of radial-artery thrombi following percutaneous cannulation for monitoring. ANESTHESIOLOGY 46: 430–432, 1977
4. Bedford RF, Wollman H: Complications of percutaneous radial-artery cannulation: An objective prospective study in man. ANESTHESIOLOGY 38:228–235, 1973
5. Bedford RF: Radial arterial function following percutaneous cannulation with 18- and 20-gauge catheters. ANESTHESIOLOGY 47:37–39, 1977

Anesthesiology
55:78–80, 1981

Postoperative Paralysis of Phrenic and Recurrent Laryngeal Nerves

ANIS BARAKA, M.D.,* KAMAL HEMADY, M.D.,† FIRYAL YAMUT, M.D.,‡ WISAL YAZIGI, M.D.,§ RINALDO F. CANALIS, M.D.¶

Postoperative paralysis of the recurrent laryngeal nerve or the phrenic nerve usually follows a direct trauma during neck or thoracic surgery.[1–4] The present report describes an unusual case of postoperative unilateral paralysis of both phrenic and recurrent laryngeal nerves in a patient undergoing surgery at a site far from the anatomic course of these two nerves.

Report of a Case

A 72-year-old man with right hydronephrosis was scheduled for right nephrectomy. Preoperative radiologic examination was normal except for degenerative changes of the lumbar spine with spur formation. He was premedicated with atropine, 0.6 mg, intramuscularly. Anesthesia was induced with the intravenous administration of thiopental, 250 mg, and succinylcholine, 75 mg. Endotracheal intubation was performed using 9-mm low-residual volume cuffed tube. The cuff was inflated with air just to the point of preventing an air leak. Anesthesia was then maintained with 75 per cent nitrous oxide and supplemented with alloferine. The patient was placed in the kidney position with the right side up. The patient was sharply angulated at the T9 to L1 level by means of a kidney bridge placed under his lower most flank. This angulation was accentuated further by "breaking" the mid-portion of the surgical table. A pillow, 15 cm in height, was placed under the patient's head. He was stable throughout surgery which lasted two hours after which the trachea was extubated. Following extubation and recovery of consciousness, the patient was hoarse which was attributed to intubation of the trachea. However, the hoarseness persisted on the second postoperative day and the patient became febrile. By indirect laryngoscopy, left recurrent laryngeal paralysis was evident. A chest roentgenogram showed left lower lobe consolidation and elevation of the left leaflet of the diaphragm. Thoracic fluoroscopy demonstrated the left diaphragmatic leaflet to be

* Professor and Chairman, Department of Anesthesiology, American University of Beirut, Beirut, Lebanon.
† Associate Professor of Surgery, Department of Surgery, American University of Beirut, Beirut, Lebanon.
‡ Resident, Department of Anesthesiology, American University of Beirut, Beirut, Lebanon.
§ Assistant Professor, Department of Anesthesiology, American University of Beirut, Beirut, Lebanon.
¶ Associate Professor of Surgery, Division of Head and Neck Surgery, Harbor-UCLA Medical Center, Torrance, California, and the UCLA School of Medicine, Los Angeles, California.

Received from the Department of Anesthesiology and Department of Surgery, American University of Beirut, Beirut, Lebanon, and the Division of Head and Neck Surgery, Harbor-UCLA Medical Center, Torrance, California, and the UCLA School of Medicine, Los Angeles, California. Accepted for publication December 31, 1980.

Address reprint requests to Dr. Anis Baraka: Department of Anesthesiology, American University of Beirut, Beirut, Lebanon.

Key words: Complication: nerve damage. Position: nerve damage. Surgery: urologic.