the shunt probably should be performed prior to surgical procedures involving the abdomen and pelvis. This safety measure has been used with success in a patient with the LeVeen shunt undergoing laparoscopy.[8] It has also been used in two patients undergoing herniorrhaphy in whom the shunt tips were found in hernia sacs.[9]

PV shunt insertion may be performed under general or local anesthesia. Monitoring for these patients should probably include a sensitive method to detect air embolism, such as capnography, mass spectrometry, Doppler monitoring, or transesophageal echocardiography. Once air embolism has been suspected, or detected, a right atrial catheter will aid removal of gas emboli. Immediate cross-clamping of the shunt should be performed at the same time to prevent further embolization. The patient should be placed in the left lateral or steep Trendelenburg position. Administration of nitrous oxide should be discontinued. Additional therapies, such as vasopressors, fluids, and cardiopulmonary resuscitation, are used as necessary. Also, application of positive end-expiratory pressure has been recommended to decrease further embolization.

In summary, a case of fatal air embolism in a 58-yr-old man following insertion of a PV shunt is presented. Resuscitation was unsuccessful and diagnosis was confirmed at autopsy.

References

1. LeVeen HH, Christoudias G, Moon IP: Peritoneovenous shunting for ascites. Ann Surg 180:580–591, 1974
2. Bettenay DAM, Maddern PJ, Oh TE, McGlew IC: The anaesthetic and perioperative management of the patient undergoing insertion of a peritoneo-venous shunt. Anaesth Intensive Care 10:108–112, 1982
3. Greig PD, Langer B, Blendis LM, Taylor BR, Glynn MFX: Complications after peritoneovenous shunting for ascites. Am J Surg 139:125–131, 1980
4. Hirst AE, Saunders FC: Fatal air embolism following perforation of the cecum in a patient with peritoneovenous shunt for ascites. Am J Gastroenterol 76:453–455, 1981
5. Jacobsen WK, Briggs BA, Thorp R, Zumwalt JR: Air embolism in association with LeVeen shunt. Crit Care Med 8:659–660, 1980
6. Gronert GA, Messick JM Jr, Cucchiara RF, Michenfelder JD: Paradoxical air embolism from a patient foramen ovale. ANESTHESIOLOGY 50:548–549, 1979
7. Wolfe JD, Tashkin DP, Holly FE, Brachman MB, Genovesi MG: Hypoxemia of cirrhosis. Detection of abnormal small pulmonary vascular channels by a quantitative radionuclide method. Am J Med 63:746–754, 1977
8. Korzarek RA, Sanowski RA, Cintora I: Laparoscopy in a patient with LeVeen shunt: Prevention of air embolism. Gastrointest Endosc 30:193–195, 1984
9. Gui D, Giangiuliani G, Veneziani A, Giorgi G, Sganga G: Inguinal hernia repair in patients with peritoneovenous shunt: Risk of air embolism. Br J Surg 73:122, 1986

Anesthesiology
70:704–707, 1989

The Diagnosis of Phrenic Nerve Block on Chest X-ray by a Double-exposure Technique

ROSEMARY HICKEY, M.D.,* SOMAYAJI RAMAMURTHY, M.D.†

Diaphragmatic paralysis due to phrenic nerve block is a frequent complication of brachial plexus blocks performed above the clavicle. Farrar *et al.* reported incidences of 36, 36, and 38%, respectively, when routine chest x-rays were taken 4 h following interscalene, subclavian perivascular, and Kulenkampff supraclavicular techniques of brachial plexus blocks.[1] Knoblanche demonstrated a higher incidence of 67% when fluoroscopic examinations were performed to evaluate diaphragmatic movement in 15 patients within 3 h following subclavian perivascular brachial plexus blocks.[2] Reports of the diagnosis of phrenic nerve block have previously relied upon clinical symptomatology, plain chest x-ray, or fluoroscopy. Recently, we have used a double-exposure technique that has allowed us to easily detect the presence or absence of phrenic nerve block on a single chest x-ray.

Report of Three Cases

Three adult males were scheduled to undergo orthopedic procedures of the upper extremity. After informed consent was obtained, each patient received a subclavian perivascular brachial plexus block with a 22-gauge 4-cm regional block needle (short bevel) according to the method described by Winnie and Collins.[3] After identifying the subclavian perivascular space containing the brachial plexus trunks, an anesthetic solution containing 1.5% xylocaine with 1:200,000 epinephrine was injected, with the volume determined by the formula: [ml = (height in inches ÷ 2) + 5]. An immobile needle technique[4] was utilized in which a small bore intravenous extension tubing was placed between the needle and the syringe containing the anesthetic solution to provide stabilization of the needle during injection.

Twenty minutes following completion of the block, each patient was evaluated for the presence of phrenic nerve block by evaluating diaphragmatic movement on chest x-ray as follows: the patient was in-

* Assistant Professor of Anesthesiology.
† Professor of Anesthesiology.
Received from the University of Texas Health Science Center at San Antonio, 7703 Floyd Curl Drive, San Antonio, Texas 78284. Accepted for publication November 23, 1988.
Key words: Anesthetic techniques, regional: brachial plexus. Phrenic nerve block. Subclavian perivascular.

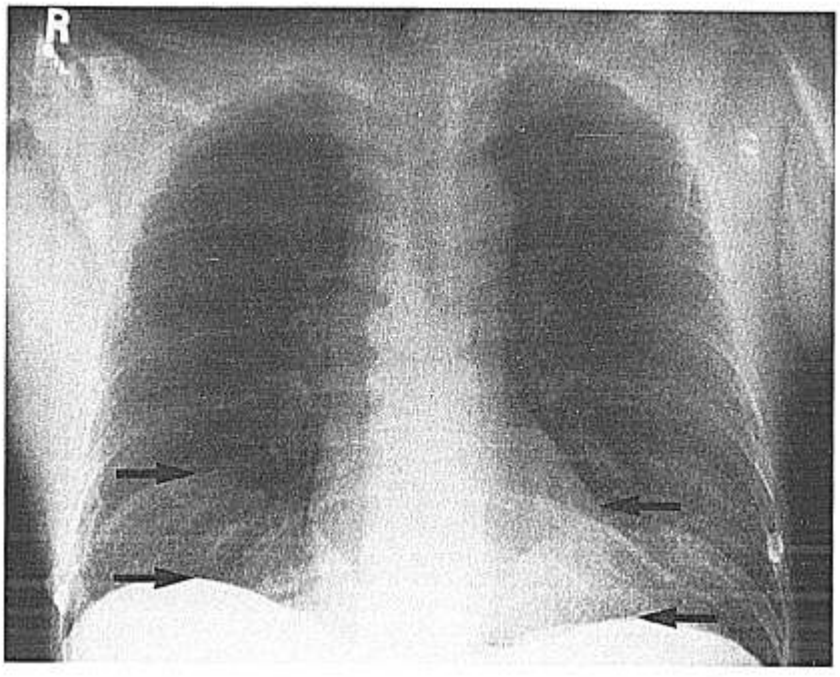

FIG. 1. Both hemidiaphragms move well between inspiration and expiration when the phrenic nerve is not blocked.

structed to take a full, deep inspiration, and the first image was taken; this was then followed by complete expiration, after which the second image was recorded on the same film. The result was a film that showed diaphragmatic position in two instances—full inspiration (in which the diaphragm is normally lowest in an unblocked patient) and expiration. In case 1, in which the phrenic nerve was not blocked, both hemidiaphragms were seen to move well between inspiration and expiration (fig. 1). When a left-sided block was present, as in case 2, the left hemidiaphragm was noted to be elevated (it is normally lower than the right side in an unblocked patient because of the presence of the liver on the right) with little movement between inspiration and expiration. The right hemidiaphragm, on the other hand, moved well between inspiration and expiration (fig. 2). In case 3, elevation and little movement of the right hemidiaphragm compared to the left was seen when a right phrenic nerve block was present (fig. 3). The patients described in case 1 and case 2 had received a subclavian perivascular block on

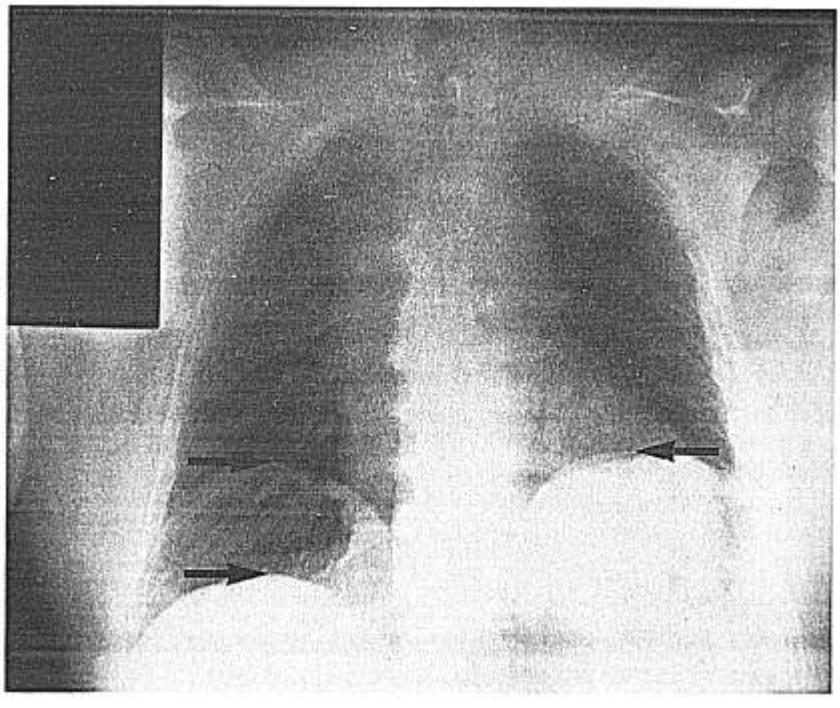

FIG. 2. The left hemidiaphragm is elevated with little movement between inspiration and expiration when the left phrenic nerve is blocked.

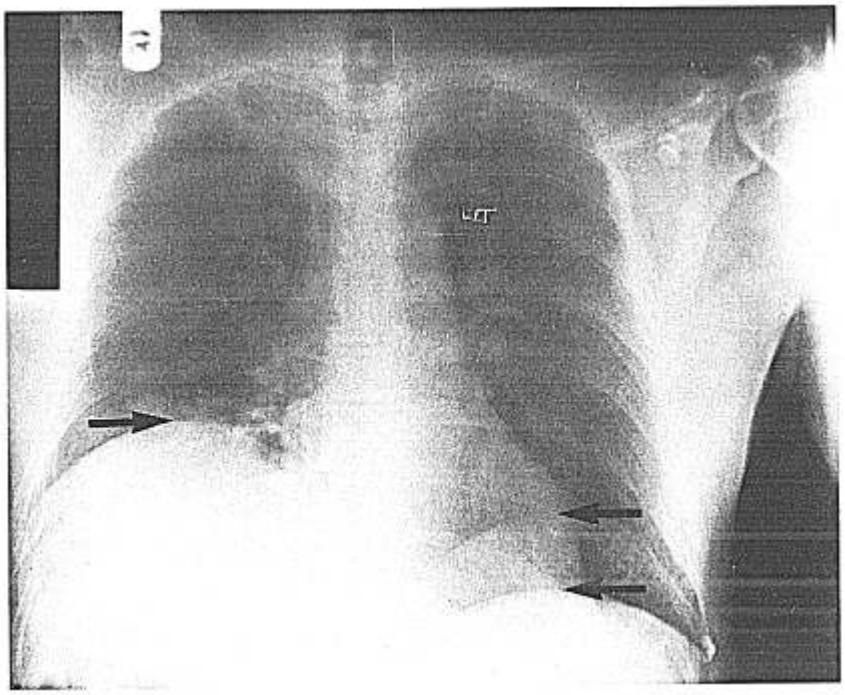

FIG. 3. Elevation and little movement of the right hemidiaphragm compared to the left is present when the right phrenic nerve is blocked.

the left side, while the patient described in case 3 had received a subclavian perivascular block on the right. None of the patients complained of dyspnea or demonstrated any other signs of respiratory distress.

DISCUSSION

The etiology of phrenic nerve block following brachial plexus anesthesia carried out above the clavicle is twofold. It may result from diffusion of local anesthetic cephalad to involve the more proximal cervical roots (C_3, C_4, C_5), or may also be a consequence of an improperly performed block with local anesthetic deposited outside the brachial plexus sheath anterior to the anterior scalene muscle. Both etiologies result in decreased mobility of the hemidiaphragm ipsilateral to the side in which the regional block was performed. Unlike a pneumothorax, in which radiographic signs may be delayed due to slow leakage of air from the lung, signs of phrenic nerve block appear early, coinciding with the onset of brachial plexus motor block.[5] The chest x-rays in our three cases were taken 20 min following completion of the regional block in an attempt to choose a time interval in which motor block would be clearly evident.

This double exposure technique easily allowed us to demonstrate the absence of phrenic nerve block or the presence of a left- or right-sided block. It has several potential advantages over previous methods used by anesthesiologists to determine phrenic nerve block. Most cases of diaphragmatic paralysis due to phrenic nerve block do not lead to respiratory symptoms or compromise. Indeed, the patients with phrenic block demonstrated above, as well as the ten patients in Knoblanche's[2] study with phrenic block demonstrated by fluoroscopy, were all asymptomatic. Therefore, if clinical symptomatology is solely relied upon to establish the diagnosis, an accurate incidence of this complication will not be reflected. When respiratory symptoms do develop, it should be kept in mind that, although pneumothorax is certainly the complication of greater concern, the most common cause of respiratory difficulty developing after any brachial plexus block performed above the clavicle is a phrenic nerve block.[5] It is important, therefore, to use a method that can predictably demonstrate this complication. A single chest x-ray taken following inspiration may demonstrate a raised left or right hemidiaphragm but, unlike the double-exposure technique, does not indicate diaphragmatic movement between inspiration and expiration. Two single chest x-rays, one taken following inspiration and one following expiration, can also demonstrate phrenic nerve block, but may be difficult to compare because of differences in technique and the degree of respiratory variation between the two films. Fluoroscopy has been the radiological "gold standard" for evaluating diaphragmatic movement. Its main disadvantage, however, lies in its practicality. The patient can be sent to the radiology suite for diagnostic testing or more sophisticated equipment as well as a radiologist can be brought to the operating room. Both of these options prove difficult in a busy operating room setting. This technique of double exposure displaying inspiration and expiration on the same film, therefore, appears to provide more information than plain chest x-

rays without the complexity of fluoroscopy. It should be considered when the diagnosis of phrenic nerve block following brachial plexus blocks performed above the clavicle is in question.

REFERENCES

1. Farrar MD, Scheybani M, Nolte H: Upper extremity block: Effectiveness and complications. Regional Anesthesia 6:133–134, 1981
2. Knoblanche GE: The incidence and aetiology of phrenic nerve blockade associated with supraclavicular brachial plexus block. Anaesth Intensive Care 7:346–349, 1979
3. Winnie AP, Collins VJ: The subclavian perivascular technique of brachial plexus anesthesia. ANESTHESIOLOGY 25:353–363, 1964
4. Winnie AP: An "immobile needle" for nerve blocks. ANESTHESIOLOGY 31:577–578, 1969
5. Winnie AP: Plexus anesthesia, Perivascular Techniques of Brachial Plexus Block. Philadelphia, W.B. Saunders, 1983, pp 228, 234

Anesthesiology
70:707–709, 1989

Intraoperative Management of Penile Erection by Using Terbutaline

T. R. SHANTHA, M.D., PH.D.*

Penile tumescence, resulting in partial or total erection during a cystoscopy or other operative procedure of the penis, can occur during regional or general anesthesia.[1–5] When this does occur, it is very difficult to perform the desired procedure and may even result in the cancellation of endoscopic or other penile surgical procedures. Although various methods and a number of pharmacologic agents have been used to control penile erection, none have been found to produce consistently good results and some are even unsafe to use in the operating room.[1,2] Four patients are described in whom terbutaline was used for treating this troublesome complication.

CASE REPORTS

Case 1. A 62-yr-old man, ASA Class II, was anesthetized for cystoscopy, retrograde pyelography, and prostate biopsy. Anesthesia was induced with thiopental iv and maintained with enflurane (1.5%) and nitrous oxide (60%) with oxygen. While preparations were being made to introduce the cystoscope, the patient developed a solid penile erection which did not disappear with the deepening of anesthesia (enflurane up to an inspired concentration of 3%) and decrease in arterial blood pressure from systolic 128 to 88 mmHg. The patient was given 0.25 mg of iv terbutaline, after which the penis became softer and the heart rate and systolic blood pressure increased from 65 to 80 bpm and 88 to 120 mmHg, respectively. Two minutes later, another iv dose of 0.25 mg terbutaline was given. The patient developed complete detumescence in less than 4 min without any other changes in vital signs. The endoscopic procedure and prostate biopsy were performed successfully.

Case 2. A 76-yr-old man, ASA Class II, was scheduled for a transurethral resection of the prostate for prostatic hypertrophy, under spinal anesthesia. The patient was given hyperbaric spinal anesthesia (L3-4 level) using 8 mg tetracaine and 0.8 ml of 10% dextrose (total volume 1.6 cc), resulting in a spinal blockade at the T8 level. As preparations were being made to introduce the resectoscope, the patient developed an erection, making it impossible to introduce the resectoscope. He was given 0.5 mg terbutaline iv. His heart rate increased from 60 to 80 bpm without any appreciable effect on the arterial blood pressure. Detumescence developed within 5 min. The resectoscope was easily introduced and the prostate was resected in approximately 1 h.

Case 3. A 24-yr-old ASA Class I man was anesthetized for a bilateral inguinal hernia repair along with a varicocelectomy. Anesthesia was induced with thiopental iv, and his trachea was intubated with the assistance of succinylcholine iv. Two surgeons operated, one on each side. After making the incision, a massive erection developed which proved bothersome to the surgeons. Anesthesia was maintained using midazolam (3 mg), fentanyl (400 μg), nitrous oxide (60%), and atracurium (15 mg) iv. Terbutaline 0.5 mg was given iv and the penis became soft and returned to its usual size within 4 min. The heart rate increased from 70 to 110 bpm and the systolic blood pressure increased from 120 to 160 mmHg. The surgery was completed in 60 min, and the trachea was extubated after reversing the neuromuscular blockade. The patient was taken to the recovery room uneventfully.

Case 4. A 45-yr-old ASA Class III man was scheduled for a transurethral resection of the prostate for benign prostate hypertrophy and carcinoma of the bladder. A spinal anesthetic (L3-4) was given using a 25-g needle and 75 mg of lidocaine with 7.5% dextrose (1.5 cc volume premixed), resulting in an adequate block at the T8 level. Preparations were being made to introduce the cystoscope. At this time, a rigid penile erection developed, making it impossible to continue with the procedure. The turgid state continued for almost 10 min without change. Terbutaline 0.25 mg was given iv and resolution of the erection took place within 4 min. The surgical procedure was completed with no noticeable changes in heart rate or arterial blood pressure.

DISCUSSION

Regardless of the type of anesthesia used, whether spinal or general, penile erection can occur.[1–5] Penile erection under spinal and epidural anesthesia is reflexogenic if it is a solid block extending well above the midthoracic

---

* Associate Chairman. T. R. Shanthaveerappa in previous publications.

Received from the Department of Anesthesiology, Georgia Baptist Medical Center, 300 Boulevard N.E., Atlanta, Georgia 30312. Accepted for publication November 23, 1988.

Address reprint requests to Dr. Shantha.

Key words: Complications: penile erection. Sympathetic nervous system: pharmacology; terbutaline.