limeters, and, therefore, strangling of the catheter seems probable. Such a device is made by nonelastic plastics, and is, therefore, uncomfortable to wear near to the skin. Totally subcutaneous indwelling injection ports are now commercially available. However, positioning such a device requires a proper surgical procedure.

Our system is easily made from the materials proposed or similar materials at hand. The measured tensile strength of the system is considered suitable when compared with the slightly larger tensile strength of the epidural catheters. This difference will, in all cases, avoid breakage of the epidural catheter centrally to the fixation device. The tensile strength of the sutures is within the same range as the fixation device, as the USP standard specifies 1.59 kp for a 2-0 suture of the applied type.

The fixation force of the device is considered sufficient to withstand accidental traction in the epidural catheter, if the catheter is tangled in clothing. If a portable pump is connected to the catheter, the device is able to carry the weight of the pump. The typical weight of a pump is 250 grams. Pain provoked by traction in the device will cause a rapid reaction in order to relieve the traction in the catheter. The system may be applied in the fixation of other types of tubings and drains.

We conclude that the described dynamic lock for fixation of epidural catheters is found able to withstand an accidental pull in the epidural catheter. The lock can resist a tensile force of at least 1 kp. Preliminary clinical experience with the device seems to show that the intended fixation of subcutaneously tunneled epidural catheters is obtained.

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An Unusual Cause of Postoperative Respiratory Failure

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Postoperative respiratory failure can be attributed to multiple causes. An infrequent cause is bilateral phrenic nerve paralysis, usually following open-heart surgery and radical neck surgery. Bilateral phrenic nerve paralysis resulting in postoperative respiratory failure is described.

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REPORT OF A CASE

The patient is a 34-yr-old, 104 kg male admitted for bilateral thoracic outlet syndrome. He was scheduled for bilateral supraclavicular first rib excision, to be performed on separate occasions. His medical history was unremarkable, with the exception of his admitting diagnosis. He was taking no medications and had no drug allergies, and he had had no prior anesthetics. Laboratory values and preoperative chest radiograph were within normal limits.

A left-sided supraclavicular first rib excision was performed under general anesthesia as the initial procedure. Induction of anesthesia consisted of d-tubocurarine 6 mg, thiopental 500 mg, succinylcholine 140 mg, and fentanyl 100 µg iv. The trachea was intubated without difficulty. Maintenance of anesthesia consisted of isoflurane, N₂O, O₂, and iv pancuronium 4 mg. The procedure lasted 2 h, and, prior to tracheal extubation, neostigmine 5 mg and glycopyrrolate 0.4 mg were
given iv. The patient was ventilating well in the operating room, and peripheral nerve stimulator demonstrated return of full train-of-four and sustained response to tetanic stimuli. The trachea was extubated in the operating room, and he was transported to the recovery room in stable condition. The patient did well postoperatively, without apparent complications, and he was discharged on the second postoperative day.

Twenty-six days later, the patient was readmitted to the hospital for right-sided supraclavicular first rib excision. He denied any health problems in the interval between admissions. Again, he underwent general anesthesia for the procedure. Induction of anesthesia consisted of d-tubocurarine 6 mg, thiopental 500 mg, succinylcholine 140 mg, and fentanyl 100 μg iv. Following tracheal intubation, anesthesia was maintained with isoflurane, N₂O, O₂, and iv d-tubocurarine 27 mg. The procedure lasted 2 h and, prior to tracheal extubation, neostigmine 5 mg and glycopyrrolate 0.4 mg were given iv. Peripheral nerve stimulation demonstrated return of full train-of-four and sustained response to tetanic stimuli; however, the tidal volume (<150 cc) was inadequate to allow tracheal extubation. The endotracheal tube was left in place, and the patient was transported to the recovery room with assisted ventilation while breathing 100% oxygen.

The patient continued to hypoventilate, despite no evidence of neuromuscular blockade by peripheral nerve stimulation. Desflurane 50 mg was given iv, and, about this time, the patient began to respond to commands. He was able to lift his head off the pillow, and he became restless with the endotracheal tube in place. Extubation was performed at this time; however, ventilation was still inadequate as the patient became cyanotic. The trachea was quickly re-intubated, and ventilation was assisted with a mask and bag apparatus. A pulse oximeter indicated that he was unable to maintain an O₂ saturation above 87% with spontaneous ventilation via a T-piece. Tidal volume measured only 150 cc, and mechanical ventilation was instituted.

Chest radiograph obtained during this time revealed bilateral elevated hemidiaphragms. Since both surgeries were done in an area near the phrenic nerve, a diagnosis of bilateral phrenic nerve paralysis was made. The surgeons had retracted the phrenic nerves during both procedures for exposure; however, he was confident that neither had been transected. The patient was transported to the ICU, and mechanical ventilation was continued. Approximately 12 h later, the trachea was extubated after a tidal volume of 1000 cc and a negative inspiratory pressure of ~80 cm H₂O was demonstrated. The patient did well, and he was discharged after 3 days in stable condition.

**DISCUSSION**

This case illustrates an unusual cause of postoperative respiratory failure. The patient had complete reversal of his neuromuscular blockade as confirmed by peripheral nerve stimulation, and he had recovered from the effects of the anesthetics. Yet, he did not ventilate adequately due to diaphragmatic paralysis. This was suspected due to paradoxical movements of the abdomen with respiration and decreased tidal volume and negative inspiratory pressure. Chest radiograph revealed bilateral elevated hemidiaphragms confirming the diagnosis.

In retrospect, the patient had paralysis of the left hemidiaphragm following his first surgery confirmed by review of postoperative chest radiographs. Frequently, patients with a paralyzed hemidiaphragm are asymptomatic, as was the case in this patient. As a result, this went unnoticed until after his second surgery. Upon emergence from anesthesia, the patient was unable to ventilate adequately due to paralysis of both the right and left hemidiaphragms. This resulted in considerably more dyspnea and disturbed pulmonary function than does unilateral paralysis. He was followed postoperatively by a Pulmonologist for 6 months. He determined by clinical examination, chest radiographs, and spirometry that function began to return to the right hemidiaphragm within 12 h following surgery, with complete return by 3 days. The left hemidiaphragm, however, remained paralyzed for approximately 6 months. The etiology of the paralysis was attributed to retraction of the phrenic nerves intraoperatively, the left apparently being more severely traumatized than the right. In this case, the interruption was not complete, and the patient regained full function of both hemidiaphragms.

There are several other causes of an elevated diaphragm detected by chest radiograph. Diaphragmatic paralysis, as discussed in this report, results from the interruption of nerve impulses through the phrenic nerve. The most common cause of this is that due to invasion of the phrenic nerve by neoplasm, usually of bronchogenic origin. The next most common cause is described as idiopathic, possibly due to an episode of acute infectious neuritis or the effects of a viral neurotoxin. Herpes zoster may cause unilateral diaphragmatic paralysis, and abnormalities of the C-3 to C-5 nerve roots may also lead to diaphragmatic paralysis. Other less common causes may also be responsible, as described by Riley.

Eventration, or congenital failure of muscular development of one or both hemidiaphragms, is another cause of an elevated hemidiaphragm on chest radiograph. It usually occurs on the left side, and, more rarely, it occurs bilaterally. Restriction of diaphragmatic motion may also appear as an elevated diaphragm on chest radiograph. A great variety of pathologic processes may account for this to include diseases of the lungs, pleura, intra-abdominal organs, and of the diaphragm itself. The diaphragm appears to react to these local irritants by relaxing or elevating.

In conclusion, it is important to be aware of diaphragmatic paralysis as a cause of postoperative respiratory failure. Phrenic nerve paralysis has been reported after trauma to the phrenic nerves following open-heart and radical neck surgery, and now, after bilateral supraclavicular first rib excision. It presents as hypventilation in the immediate postoperative period in the presence of complete reversal of neuromuscular blocking agents in an awake patient. Based on this case, bilateral supraclavicular first rib excision probably should be performed on separate occasions.

Furthermore, thorough assessment of diaphragmatic function should be done after the first surgery and prior to operating on the contralateral side. If any evidence of
paralysis exists, full return of function should occur prior to performance of surgery on the contralateral side.

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Fire Following Use of Electrocautery during Emergency Percutaneous Transtracheal Ventilation

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Fires can occur intraoperatively, despite the use of “nonflammable” anesthetics. Usually electrocautery is the source of ignition for a variety of flammable materials, including enteric gas and surgical drapes.1-3 Recently, the surgical laser has been the ignition source for several endotracheal tube fires.4 Administration of oxygen or nitrous oxide/oxygen mixtures serve to enhance combustion. Percutaneous transtracheal ventilation allows oxygenation and ventilation of the patient when attempts at ventilation, both via a bag and mask apparatus and endotracheal intubation, fail.5,6 This case illustrates the fire hazard associated with percutaneous transtracheal ventilation performed during an emergency tracheostomy at which electrocautery was used.

REPORT OF A CASE

A 68-y-old male underwent panendoscopy for staging of a 3 by 3 cm mass of the left neck. The trachea was intubated for that procedure with a 6.5 mm endotracheal tube with a stylet and a Mac 3 laryngoscope blade. The glottis was not well seen due to an “anterior” larynx, but intubation was performed easily on the first attempt. Panendoscopy was normal, and the patient was scheduled for biopsy of the neck mass and probable left neck dissection.

Four days later, when the patient presented for his second procedure, he was asymptomatic, except for a mild sore throat. There was no stridor or hoarse voice. After placement of monitors, including an arterial line and a pulse oximeter, anesthesia was induced iv, succinylcholine was administered, ventilation was controlled without difficulty, and endotracheal intubation was attempted. The glottis could not be visualized, and the epiglottis was noted to be edematous during the initial intubation attempt. Despite several attempts with curved and straight laryngoscope blades, small endotracheal tubes, and an Eickmann stylet, intubation could not be performed. Ventilation was maintained via a mask and bag between intubation attempts, and oxygen saturation was well maintained. However, ventilation was becoming distinctly more difficult after each attempt. Because there appeared to be a progressive obstruction of the airway, the etiology of which was unknown, it was decided to establish percutaneous transtracheal ventilation and perform a tracheostomy. A 14-gauge iv catheter was inserted through the cricothyroid membrane, secured with a suture, and ventilation was begun with 100% oxygen at 50 psi. Analysis of arterial blood gases confirmed effective oxygenation and ventilation: pH 7.42, PaO₂ 33 mmHg, PaCO₂ 22 mmHg. Oxygen saturation, as measured by pulse oximetry, remained >95% throughout the procedure.

Betadine solution, which contains no volatile materials, such as alcohol, was used to prep the skin. The patient was draped for tracheostomy with the anesthesiologist holding onto the cricothyroid catheter, just under the drape. Anesthesia was maintained with intermittent doses of thiopental and succinylcholine. The procedure proceeded uneventfully until the surgeon divided the thyroid isthmus with the cautery. A flash of light was observed in the field which appeared to travel under the drapes in a cephalad direction. A moment later, the anesthesiologist noted that his middle finger felt extremely hot. Upon withdrawing his hand from under the drape, a plastic glove covering his hand was burning. The glove was removed and the patient’s head was uncovered. Two cloth drapes next to the right side of the patient’s neck were in flames. These were removed and extinguished. The tracheostomy was completed without further difficulty, and the left neck dissection was also performed. The anesthesiologist suffered a deep second degree burn of his middle finger, and the patient suffered a superficial second degree burn of the right side of his neck. Both burns are now well healed. Panendoscopy was performed following completion of the neck dissection. There were no burns of the airway. Severe, diffuse edema of the larynx was noted, and the cords were very difficult to visualize, accounting for the difficulty in attempting to intubate the trachea.

DISCUSSION

Prior to 1955, the most common fuel for operating room fires was flammable anesthetics. In the 15-yr period


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