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Bronchial Rupture Associated with the Use of a Double-Lumen Tube in a Small Adult

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Isolation of either lung using a double-lumen endobronchial tube is frequently performed as part of the anesthetic management of patients undergoing major thoracic surgery. Bronchial rupture is a serious potential complication of this technique, especially with the use of the older Carlens, White, and Robertshaw double-lumen tubes.[1–3] These tubes are made of red rubber. They have low-volume and high-pressure cuffs that sometimes inflate asymmetrically, leading to deviation of their tips toward the bronchial wall. Carlens and White tubes, in addition, have a carinal hook which increases their potential for causing tracheobronchial damage.

The newer polyvinyl chloride (PVC) double-lumen endobronchial tubes have been shown to cause fewer complications than the earlier ones.[4,5] They are softer, more flexible, and have low-pressure and high-volume bronchial and tracheal cuffs. It is too early to determine whether their use is associated with a lower incidence of bronchial rupture because the complication is rare, and PVC tubes have only come into use in recent years. One case of bronchial rupture associated with their use has already been reported.[6] We report here a similar complication and discuss a possible different contributing factor.

CASE REPORT

A 74-yr-old female presented with right shoulder pain of recent onset. Her past medical history was significant for a long history of smoking but was otherwise unremarkable. Physical examination revealed a patient, 95 pounds, 5-feet tall, with no other significant findings. Chest x-ray showed a highly calcified tracheobronchial tree and a right upper lobe mass that was recently diagnosed by needle biopsy as squamous cell carcinoma. Bone scan suggested involvement of two adjacent ribs. There was no evidence of mediastinal involvement or distant metastasis. The rest of her laboratory work-up was unremarkable apart from pulmonary function tests that showed a mild obstructive pulmonary disease. She was scheduled for a right exploratory thoracotomy.

When the patient arrived in the operating room, an epidural catheter was inserted at the lower thoracic region for postoperative administration of opioids. General anesthesia was then induced with sodium thiopental and maintained with oxygen, isoflurane, and fentanyl with pancuronium added for muscle relaxation. Following induction of anesthesia, the trachea and left main-stem bronchus were intubated with a 35F left PVC double-lumen endobronchial tube (Broncho-Cath®). After the trachea was intubated, the stylet was removed, the tube turned 90° counterclockwise and advanced until moderate resistance was encountered. The tracheal and bronchial cuffs were then inflated until moderate tension was palpated in the pilot balloons, according to the technique described by Benumof.[7] This required 5 ml and 1 ml of air, respectively. Bilateral ventilation and lung isolation were confirmed by auscultation. The patient was then turned to the left lateral decubitus position. The position of the tube was reconfirmed by auscultation and by fiberoptic bronchoscopy. The blue bronchial cuff was seen in the optimal position, just distal to the carina, without having to make any readjustments. Following right thoracotomy, initial collapse of the right nondependent lung was easily accomplished. A small amount of mediastinal emphysema was noticed at that time. Two subsequent deflations of the nondependent lung required slight readjustment of the endobronchial tube position. When the nondependent lung failed to deflate completely on each occasion, it was noted that the tube had migrated proximally about ½ inch, compared with its original position in relation to the patient's teeth. Without confirmation with fiberoptic bronchoscopy, it was felt that this must have resulted in the bronchial cuff slipping out of the left main-stem bronchus, resulting in a compromise of its seal and an air leak into the right lung. The bronchial cuff was, therefore, deflated, the tube advanced to its original position, and the bronchial cuff reinflated. On each occasion it was then possible to completely deflate the nondependent lung. Arterial oxyhemoglobin saturation remained above 98% throughout the procedure.

The patient underwent a right upper lobectomy and partial excision and reconstruction of the chest wall. At the conclusion of the resection, while checking the resected bronchial stump for leaks, air bubbles were detected arising from the mediastinum. Further dissection identified the source of the air leak to be a 3–4 cm laceration in the left main-stem bronchus. The bronchial cuff was seen herniating through the laceration. The tube was pulled back and the laceration repaired using interrupted 3–0 Prolene sutures. A pedicle flap of parietal pleura was mobilized behind the esophagus and attached to the suture line.

The postoperative course was complicated by pulmonary atelectasis and pneumonia, but the patient ultimately made full recovery and was discharged from the hospital in stable condition. There was no compromise of the diameter of her left main-stem bronchus following the repair as judged by comparing the preoperative and discharge chest x-rays.

DISCUSSION

Tracheobronchial rupture has been mainly reported with the use of the red rubber double-lumen endobronchial tubes. Guernelli[1] reported five cases of tracheobronchial rupture in 2,700 patients following tracheal intubation with a cuffed Carlens endobronchial tube. The most common sites of rupture in these patients were the distal portion of the trachea and left main-stem bronchus

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in the posterior membranous part or its junction with the cartilaginous part. In three patients, the bronchial rupture was detected intraoperatively. The surgeon noted the tear on two occasions. The third patient presented with a serious ventilatory insufficiency. Primary repair of the rupture was undertaken in the three patients who made uneventful recovery. One other patient presented with postoperative inexhaustible pneumothorax. He died 4 days later from mediastinitis despite emergency repair of the tear. The fifth patient had an uncomplicated postoperative course. A control bronchoscopy performed 10 days later revealed a small tracheobronchial laceration that was treated conservatively. Foster[2] reported a case of right main-stem bronchial rupture associated with the use of a White endobronchial tube. The tear was noted by the surgeon following a left pneumonectomy. It was repaired but the patient died 6 days postoperatively. Heiser[3] reported a case of bronchial rupture complicating the use of a Robertshaw double-lumen tube. Following a right upper lobectomy, the right upper-lobe bronchus was tested for air leaks by applying sustained positive pressure. Bubbles were noticed to arise from the mediastinum. The source was found to be a split in the wall of the left main-stem bronchus that was repaired and the patient made full recovery. None of the authors tried to identify the direct causative factor responsible for these complications.

The only other published case of bronchial rupture associated with the use of the newer PVC double-lumen tubes was reported by Burton.[4] The presenting signs of rupture in this case were increased ventilatory difficulty shortly after deflating one lung and increasing mediastinal emphysema. The author felt that overdistention of the bronchial cuff was the primary reason for the bronchial rupture. After initially inflating the cuff with 2–3 ml of air, he aspirated back 4–5 ml and attributed the difference to N_2O diffusion into the cuff. This patient also made full recovery.

Bronchial rupture in the case presented here most likely occurred during the initial intubation and positioning period because the mediastinal emphysema was detected early in the case. This was a totally unexpected finding following what was felt to be a routine uncomplicated intubation. The only aspect in which this patient differed from the average population requiring double-lumen intubation was her size. Therefore, we retrospectively examined the possibility that the bronchial trauma was the result of her left main-stem bronchus being too small to accomodate a 35F endobronchial tube, which is the smallest size available. Merendino[8] measured the luminal diameters of various areas of the lower trachea and bronchi in 57 fresh human cadavers. He found that the average internal diameter of the left main-stem bronchus in female patients was 12 mm. The range was 8.5–15.5 mm. This patient, weighing 95 pounds and being 5 feet tall, is likely to fall on the lower end of that range. To verify this assumption, we measured the diameter of her left main-stem bronchus on the preoperative PA chest x-ray and found it to be 9 mm. Since the size of intrathoracic structures appear magnified on PA chest films, the actual size can be calculated by applying the following equation:[9]

$$\text{Actual Size} = \text{Projected Size} \times \frac{\text{The distance between the x-ray tube and the object (h)}}{\text{The distance between the x-ray tube and the film (H)}}$$

(H) is a standard 6 feet. (h) equals (H) − the distance between the bronchus and the anterior chest wall, which can be measured on a lateral chest film. The diameter of this patient's left main-stem bronchus was calculated to be 8.4 mm. The external diameter of the bronchial tube of a 35F left sided Broncho-Cath® endobronchial tube is 9.5 mm.[10] One can therefore extrapolate that the bronchial tube, with its surrounding cuff, would fit very tightly in the patient's left main-stem bronchus and that inflating the cuff with as little as 1 ml of air would lead to a significant distention of the bronchial wall. This could have been a major contributing factor that lead to the bronchial rupture. The very tight fit of the bronchial tube in the slightly cone-shaped bronchus might have also contributed to the tendency of the tube to migrate proximally during the case.

It has been recommended that the largest PVC double-lumen tube that can be passed easily should be used.[11] In view of the wide range of bronchial diameters between different individuals, and the fact that the definition of an easy passage of a double-lumen tube can be very variable, we feel that awareness of the external diameter of the bronchial tube and the diameter of the patient's bronchus should make the choice of the tube size more objective.

Another important consideration is the fact that reliance on palpating the tension in the external pilot balloon while inflating the bronchial cuff is very subjective. Some authorities recommend direct measurement of the balloon pressure.[12] Benumof[13] describes a more exact technique: for a left double-lumen tube, after the tracheal cuff is inflated, the right (tracheal) lumen is opened to air and the left lung is inflated. Air leak from the open right lumen is sought and the bronchial (left) cuff is then inflated until the leak is eliminated. This technique is more objective

and should decrease the chances of overinflation of the bronchial cuff.

Other recommendations to protect against tracheobronchial rupture during the use of double-lumen tubes include removing the stylet after the tip of the tube is passed through the cords, deflating the tracheal and bronchial cuffs when repositioning the patient or the tube and inflating the bronchial cuff only during one-lung ventilation. If the bronchial cuff fails to seal with 2–3 ml of air, the size and position of the tube should be reassessed. One should also check the integrity of the intubated bronchus with the bronchial cuff deflated at the time of testing the resected bronchus for air leaks. If N_2O is used during bronchial cuff inflation, frequent checking of the balloon pressure has been recommended.

Bronchial rupture associated with the use of the PVC double-lumen tubes is a serious potential complication. Extreme care with positioning and bronchial cuff inflation is, therefore, needed. Selecting the appropriate tube size for a given patient may require more accurate estimation by calculating the diameter of the bronchus to be intubated from PA and lateral chest x-rays. The appropriate tube size for a given bronchial diameter remains to be determined.

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Inadvertent Development of Subatmospheric Airway Pressure during Cardiopulmonary Bypass

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Gas sampling devices are widely used to monitor both anesthetic and respiratory gases during the perioperative period. Although misinformation derived from monitoring artifacts[1,2] may lead to errors in patient management, devices to qualitatively analyze gases are generally viewed as safe, posing little risk of physical injury to the patient. We describe here a circumstance where a noninvasive monitor, *via* its mechanical sampling function, created a potential hazard for a patient during cardiopulmonary bypass.

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Case Report

A 57-yr-old man, scheduled for coronary revascularization and mitral valvuloplasty, was monitored prior to induction *via* radial and pulmonary artery catheters, electrocardiography, and pulse oximetry. After induction of general anesthesia and tracheal intubation, additional respiratory monitors were applied, including a time-shared mass spec-