Tracheo-Innominate Artery Fistula After Tracheostomy

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Fistula formation between the trachea and the innominate artery is a rare complication of tracheostomy (1). The survival rate in patients who develop bleeding from a tracheo-innominate artery fistula (TIF) has been reported as 14.3%, and only patients who received immediate surgical treatment survived (2). Of those patients who develop a TIF, 78% do so within the first 3 wk after tracheostomy (3). One of the proposed mechanisms of fistula formation is mucosal necrosis due to pressure caused by the elbow, tip, or cuff of the tracheostomy tube (2).

Clinical presentations and treatment of TIF have been described mainly in the surgical literature (1–7). However, because anesthesiologists may be involved in treating this emergency, they must be familiar with the therapeutic steps. We present a patient who developed a TIF and died as a consequence of massive hemorrhage into the tracheobronchial tree with asphyxia. We discuss potential preventative measures that should be followed to decrease the probability of formation of a tracheo-arterial fistula, as well as important diagnostic and therapeutic steps the anesthesiologist must take in managing this severe tracheostomy complication.

Case Report

A 22-yr-old, 80-kg man (height 175 cm) suffered a severe head injury in a motor vehicle accident. On arrival at the hospital, his trachea was intubated. A computed tomography scan of the head and cervical spine showed an epidural hematoma, fracture of the second cervical vertebrae, multiple fractures of the occipital bone, and dislocation of the left atlantoaxial joint without spinal canal compromise. Suboccipital osteoclastic craniotomy and evacuation of the epidural hematoma were performed immediately, and the neck was conservatively stabilized. Because there was no dislocation of the cervical vertebrae or risk to the cord, further surgical intervention was not deemed necessary. Postoperatively, the patient was transferred to the intensive care unit, where his breathing was maintained with mechanical ventilation. He was comatose for the first 5 postoperative days (PODs). On POD 6, he regained some spontaneous movement of his left upper and lower extremities. On POD 9, the patient began to communicate and was aware of his surroundings. Because his breathing remained ventilator-dependent, a tracheostomy was performed on POD 11 at the level of the second, third, and fourth tracheal rings with a transverse incision. A low-pressure size 8 cuffed tracheostomy tube was placed. On POD 16, the patient became febrile, and the urine culture was positive for pseudomonas. Antibiotic therapy was begun, after which the patient became afebrile on POD 17; on POD 26, antibiotics were discontinued. On POD 30, minimal bleeding from the tracheostomy was noticed. The tracheal cuff was deliberately overinflated and the bleeding temporarily ceased. However, 1 h later, while being transported to the operating room (OR) for surgical exploration, massive tracheal bleeding occurred. Digital compression of the bleeding site through the tracheostomy opening against the sternum was attempted without success, and cardiac arrest ensued. Immediately after the bleeding started, the tracheostomy tube was replaced with an oral endotracheal tube. Despite all resuscitation attempts, including replenishment of intravascular volume with colloid solution (hetastarch), lactated Ringer's solution, and whole blood, as well as cardiopulmonary resuscitation efforts (chest compression and epinephrine), the patient died. An autopsy revealed massive blood aspiration into the lungs from a large TIF. Histopathologic examination of the fistula revealed necrosis at the tracheal opening, which suggests that a necrotic ischemic process started at the trachea and progressed toward the innominate artery.

Discussion

TIF is a life-threatening complication of tracheostomy that usually presents with acute and massive tracheal bleeding. Without prompt surgical intervention, the outcome of this complication is grave. Therefore, a high index of suspicion should be maintained in any patient with tracheostomy and subsequent hemoptysis (1). Premonitory minimal tracheal bleeding and pulsation of the tracheostomy tube synchronous with the heart beats have been reported as warning signs of

Accepted for publication December 23, 1998.

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0003-2999/99/$5.00

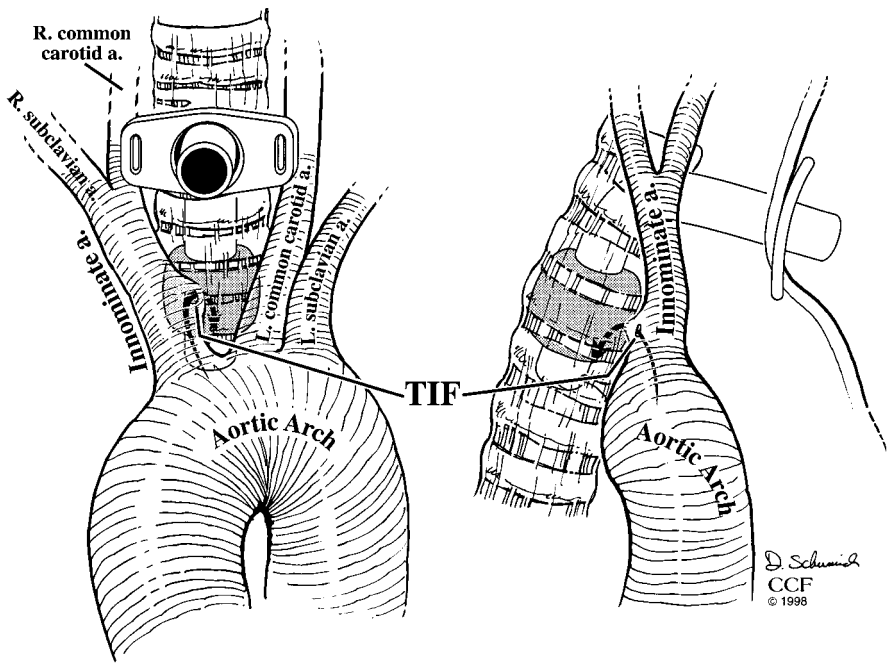

Figure 1. Anatomic relationship between the trachea and the innominate artery (anteroposterior and lateral view). The innominate artery usually traverses the trachea at the level of the ninth tracheal ring; however, it can be located as high as the sixth tracheal ring. The tip or the tracheostomy tube cuff can erode the mucosa, causing the tracheo-innominate artery fistula (TIF). Reprinted with the permission of the Cleveland Clinic Foundation.

massive hemorrhage from TIF (6–8). Indeed, in our patient, a sentinel bleed occurred 60 min before massive airway hemorrhage. However, pulsation of the tracheostomy tube has been noted in only 5% of patients who were later found to have had a TIF (9). Such pulsation was not observed in our patient. Although hemorrhage is a relatively frequent complication of tracheostomy, bleeding due to TIF is very rare. In general, there are two types of hemorrhage from a tracheostomy site: early and late. Early hemorrhage occurs within a few hours postoperatively and is most often attributed to either insufficient surgical hemostasis or preexisting coagulopathy. Late hemorrhage occurs days or months after surgery and may be due to tracheostomy site infection, coagulation problems, tumor invasion, and, in very rare instances, TIF (4). The major arteries involved are the innominate, common carotid, inferior thyroid, superior thyroid, or the aorta, in cases of aortic aneurysm. The most commonly described source of the bleeding is from the fistula connecting the innominate artery and trachea (Figure 1) (10), as in our patient. The innominate artery has a close anatomical relationship to the trachea. This artery usually traverses the trachea at the level of the 9th tracheal ring but may vary between the 6th and 13th tracheal rings (11).

Mucosal necrosis induced by the long-standing pressure exerted by the tracheostomy tube cuff caused our patient's arterial fistula. This was confirmed on postmortem histopathological examination of the trachea and innominate artery specimens; necrosis was mainly located at the tracheal wall side at the level of the tracheostomy tube cuff. Cooper and Grillo (12) reported that tracheal injury is mostly associated with high-pressure tracheal cuffs. Although the incidence of tracheal damage has lessened with the introduction of large-volume low-pressure cuffs, it may still occur. Tracheal capillary pressure ranges between 20 and 30 mm Hg. In humans, tracheal blood flow is impaired at 22 mm Hg and is totally obstructed at 37 mm Hg (13). Therefore, to avoid mucosal pressure necrosis, the use of low-pressure tracheal cuffs inflated to $<$20 mm Hg is recommended. In addition, intermittent deflation of the cuff during long-term ventilation may reduce the risk of mucosal ischemia (4). We currently practice the "no leak technique," in which our respiratory therapists in each shift (three times daily) deflate the tracheal tube cuff on chronically ventilated patients and reinflate it just until the leak stops. Finally, tracheostomy tube movements during prolonged ventilation should be minimized by using flexible connecting tubing (1). Interestingly, this rare complication has been most often described after tracheostomy in patients with head injuries, presumably because of the relentless movement of the patient's head and neck (4). Therefore, preventing excessive head movements (sedation, muscle relaxation) of patients on long-term ventilatory support should also be considered.

Approximately 50% of patients with TIF have relatively minor bleeding that stops spontaneously before the diagnosis (14). When TIF is suspected, the patient must be immediately transported to the OR, and careful fiberoptic bronchoscopy should be performed simultaneous with slow cuff deflation, followed by gradual withdrawal of the tracheostomy tube (Figure 2). Cooper (5), however, suggested that rigid

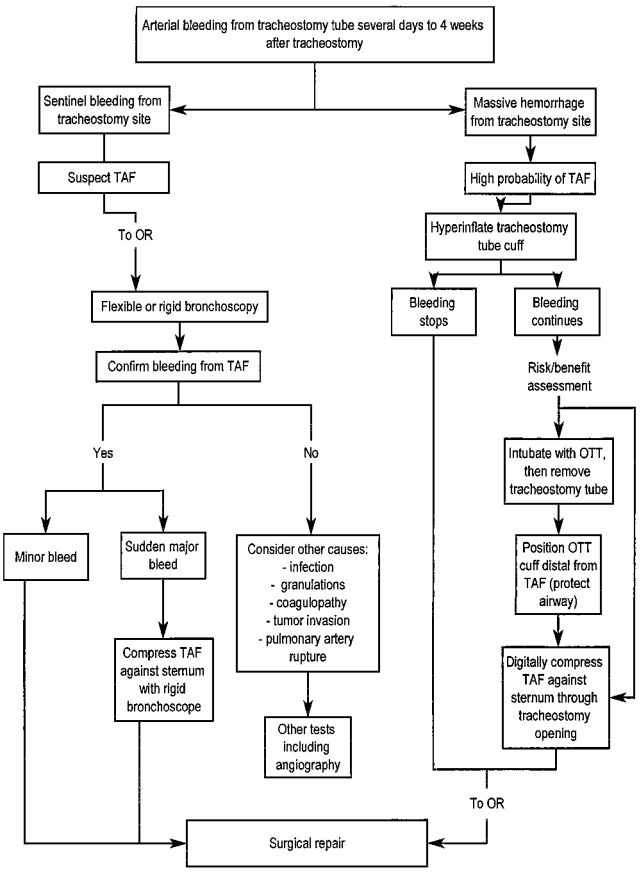

Figure 2. Algorithm of proposed management of the bleeding from a tracheo-arterial fistula (TAF). Bleeding from TAF may present as sentinel bleeding or massive hemorrhage. If hyperinflation of tracheostomy tube cuff does not stop the bleeding, two options are available. First, reintubate the trachea with an orotracheal tube (OTT) and position the cuff distally from the bleeding site, then digitally compress the bleeding artery against the sternum through the tracheostomy opening. Second, digitally compress the bleeding artery with the tracheostomy tube *in situ* (tube exchange may risk of loss of the airway). This compression must be maintained during the entire transport to the operating room (OR).

rather than fiberoptic bronchoscopy should be performed, not only to examine the source of bleeding, but also to control against possible sudden hemorrhage by compressing the bleeding innominate artery against the sternum. Angiography is rarely helpful, is not recommended, and may delay definitive diagnosis and treatment (2). If brisk hemorrhage occurs, tracheostomy tube cuff hyperinflation as a first step may temporarily control the bleeding (14). When the suspicion of a fistula is high, an orotracheal tube should be inserted with the intent to advance it distally past the tracheostomy site and TIF simultaneous with removal of the tracheostomy tube. This maneuver will secure the airway in case of sudden bleeding, which could make visualization for placement of the endotracheal tube very difficult. This will also provide an airway during diagnostic bronchoscopy. If overinflation of the tracheostomy tube cuff or endotracheal tube cuff as a first maneuver fails to control the bleeding, the orotracheal tube should be positioned distal to the bleeding site, and digital compression of the innominate artery through the tracheostomy tract must be performed (15). With an index finger inserted through the tracheostomy tract in the pretracheal fascial plane, the innominate artery must be bluntly dissected from the trachea and compressed against the sternum. An alternative and simpler maneuver is to compress the innominate artery by placing a finger into the trachea through the stoma and compressing the opening of the bleeding fistula from inside the trachea against sternum. This digital compression should be maintained during transport of the patient to the OR until surgical control of the bleeding is accomplished. Although this maneuver is only a temporary measure, it successfully stops bleeding in approximately 90% of patients (14). However, immediate surgical repair is the only life-saving procedure (1).

Management of bleeding from a TIF can be a challenging task for the anesthesiologist who may be involved in controlling both the airway and bleeding by digitally compressing the bleeding site. The key to preventing TIF formation is careful management of tracheotomized patients, prompt treatment of tracheostomy site infection, prevention of tracheal injury by avoiding prolonged cuff overinflation, and prevention of excessive head movement.

The authors thank Drs. Paula Bokesch and Isaac Eliachar for carefully reviewing this manuscript.

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