Hyperbaric oxygen therapy for the treatment of anastomotic complications after tracheal resection and reconstruction

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Objective: Failure of anastomotic healing is a rare but serious complication of laryngotracheal resection. Treatment options include reoperation, tracheostomy, or T-tube placement. Hyperbaric oxygen therapy (HBOT) is the delivery of 100% O_2 at pressures greater than 1 atm, and has been shown to enhance wound healing after tracheal resection in animal models. To date, there have been no reports describing its usefulness in humans after tracheal resection.

Methods: Five consecutive patients with varying degrees of failed anastomotic healing, from necrotic cartilage to partial separation identified by bronchoscopy were treated with HBOT. HBOT was administered for 90 minutes via a hyperbaric chamber pressurized to 2 atm with 100% oxygen. Patients were treated with daily or twice daily HBOT. Four of 5 patients had buttressing of the anastomosis by strap muscle at the initial surgery.

Results: All patients had evidence of anastomotic healing on bronchoscopy. None of the patients in this series required tracheostomy, T-tube, or reoperation after initiation of HBOT. On average it took 9.6 days for healing to occur (5-14 days). The size of the anastomotic defect ranged between 3 and 13 mm. One patient required bilateral tympanostomy tubes for inner ear discomfort and experienced blurry vision as complications of HBOT. One patient developed tracheal stenosis from granulation tissue that required bronchoscopic debridement.

Conclusions: In select patients with anastomotic complications after tracheal resection, HBOT may aid in healing and avoid tracheostomy. Future investigations are necessary to further define the benefits of HBOT in the management of airway anastomotic complications. (J Thorac Cardiovasc Surg 2014;147:1030-5)

Anastomotic separation after tracheal resection and reconstruction (TRR) is rare, occurring in only 4% of procedures.[1] However, anastomotic separation carries significant morbidity and a 0.6% chance of mortality.[1] Risk factors for anastomotic complications include diabetes, resection length greater than 4 cm, reoperation, laryngotracheal resections, age less than 17 years, and preoperative tracheostomy.[1] We have previously described our experience with anastomotic complications after TRR. Treatment of anastomotic complications included reoperation, revision of the anastomosis, and T-tube or tracheostomy placement.[1]

Hyperbaric oxygen therapy (HBOT) is the administration of 100% oxygen at pressures greater than 1 atm. It is currently used to increase healing of diabetic lower extremity wounds and radiation injuries. HBOT is believed to promote wound healing by increasing angiogenesis and collagen synthesis.[2] Recent experimental evidence in animals has shown that it may stimulate increased healing of the trachea after resection and reconstruction.[3,4] We used HBOT in 5 consecutive patients with anastomotic complications after tracheal resection and followed their clinical outcomes.

METHODS

This is a retrospective review of 5 consecutive patients treated at a single institution from 2009 to 2012. Approval for this study was obtained from the Institutional Review Board. Each patient previously underwent a tracheal resection and anastomosis and was found to have evidence of failed anastomotic healing on bronchoscopic examination between postoperative days 5 and 7. Our technique for tracheal and laryngotracheal resection has been described in previous publications.[5-8] Bronchoscopic findings ranged from necrotic cartilage to partial separation of the tracheal anastomosis. All patients were treated as inpatients and HBOT was administered for 90 minutes via a hyperbaric chamber pressurized to 2 atm with 100% oxygen. The goal number of HBOT treatments was 20. Initially in our series, patients were treated with daily HBOT, however later patients received twice daily HBOT. Four of 5 patients in this series had careful buttressing of the primary anastomosis with sternohyoid and sternothyroid strap muscles. One patient with anastomotic separation did not undergo buttressing of the anastomosis with muscle and underwent reexploration, revision of the anastomosis, and tracheostomy placement. In this patient, HBOT was started after the reoperation procedure. All patients received intravenous broad-spectrum antibiotics and 3 of 5 patients also received treatment with tobramycin nebulizers administered twice daily. Heliox was used in patients as clinically indicated.

RESULTS

The characteristics of the patients in this series were as follows: the mean age was 46 years (range, 20-63 years),

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Disclosures: Authors have nothing to disclose with regard to commercial support.

Read at the 39th Annual Meeting of The Western Thoracic Surgical Association, Coeur d'Alene, Idaho, June 26-29, 2013.

Received for publication June 25, 2013; revisions received Oct 9, 2013; accepted for publication Nov 8, 2013; available ahead of print Dec 16, 2013.

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0022-5223/$36.00

http://dx.doi.org/10.1016/j.jtcvs.2013.11.014

Abbreviations and Acronyms
CT = computed tomography
HBOT = hyperbaric oxygen therapy
POD = postoperative day
TRR = tracheal resection and reconstruction

3 patients had idiopathic tracheal stenosis, 2 patients had postintubation tracheal stenosis, 3 patients were female, and 1 patient was a reoperation (Table 1). Two patients with anastomotic complications in this series had diabetes and 1 had a preoperative tracheostomy (Table 1). The clinical presentation of anastomotic complications varied (Table 2). Two patients had cervical erythema, 3 patients presented with subcutaneous air, 1 had fever, 2 had leukocytosis, 1 had stridor, and 1 had hemoptysis. Overall, 4 patients had 2 or more clinical symptoms at the time the anastomotic complication was recognized.

On bronchoscopic examination, all the patients had evidence of necrosis at the anastomotic site. Three patients had defects of the anterior cartilage; 2 patients had necrosis at the lateral cartilaginous aspect of the anastomosis. The range in size of the anastomotic defect was estimated to be between 3 and 13 mm (Table 2). Two patients had a significant separation of the anastomosis visible on bronchoscopy (Table 2). Two patients had positive bacterial cultures, the other 3 patients either did not have cultures or their tracheal cultures demonstrated normal respiratory flora (Table 2).

At the time of discharge, all patients underwent bronchoscopy and had evidence of anastomotic healing. None of the patients in this series required reoperation after initiation of HBOT. On average it took 9.6 days for healing to occur (range, 5-14 days) (Table 3). The mean number of HBOT sessions was 13.2 (range, 5-21) administered either daily or twice daily (Table 3). Patients in this series had on average 2.6 bronchoscopies (range, 1-4) performed after the initiation of HBOT and before discharge (Table 3). The mean interval between bronchoscopies was 5 days (range, 3-8 days) (Table 3). The average length of stay was 22 days (range, 15-31 days) (Table 4).

Outcomes are listed in Table 4. There were no postoperative deaths. Complications were minor and included 1 patient who required bilateral tympanostomy tubes for inner ear discomfort. The same patient also experienced temporary blurry vision after receiving HBOT. Both of these complications resolved. Three patients developed granulation tissue at the anastomosis with 1 patient requiring 2 bronchoscopic debridements. At follow-up, ranging from 1 to 3.5 years, all patients remain asymptomatic and none have required subsequent dilation or persistent need to treat granulation tissue.

Case 1

The patient was a 52-year-old man with obesity, diabetes, coronary artery disease, gastroesophageal reflux disease, and fibromyalgia who required a tracheostomy in February 2009 after undergoing multiple nasal and pharyngeal procedures for obstructive sleep apnea. The tracheostomy site was complicated by recurrent infections. He was decannulated in May 2009. He subsequently developed stenosis at the site of his tracheostomy stoma and was referred for definitive resection and reconstruction after undergoing 2 failed dilation procedures. He had a 3-cm long stenosis 3 cm below the vocal cords.

TRR was performed through a collar incision with the addition of a partial sternotomy through the manubrium to aid in exposure. The anastomosis was to the cricoid cartilage and a sternohyoid muscle flap was used to buttress the anastomosis. Postoperatively, the patient did well until postoperative day (POD) 7 when he developed erythema of the neck in addition to leukocytosis. He was placed on broad-spectrum antibiotics. Bronchoscopy was performed and persistent necrosis of the anterior cartilage at the anastomosis was observed. A repeat bronchoscopy on POD 14 revealed progression of the necrosis and visualization of the strap muscle buttress. Frank dehiscence of the anastomosis did not occur. HBOT was started that day after a computed tomography (CT) scan of the neck did not reveal subcutaneous air, abscess, or fluid collection. He completed 6 sessions of HBOT between POD 14 and 20. On POD 21, bronchoscopic examination demonstrated granulation tissue and a gathering of sutures at the anastomosis. The airway was intact, and the patient was otherwise doing well. Bronchoscopic debridement of the sutures and granulation tissue was undertaken on POD 27 and POD 31. He was discharged on POD 32. The patient remains asymptomatic 3.5 years later with mild stenosis (20%) on bronchoscopic examination.

Case 2

The patient was a 20-year-old man who developed tracheal stenosis after tracheostomy after a motor vehicle accident. In March 2010, he underwent a tracheal reconstruction with an auricular cartilage graft and T-tube placement. The T-tube was removed but after 5 weeks, a large amount of scar and granulation tissue was noted on bronchoscopy. A tracheostomy was placed and he was referred to our institution 8 months later when it was evident that the graft had failed. Radiologic and bronchoscopic findings revealed a 3.5-cm long narrowing that started 1.5 cm below the vocal cords. Tracheal resection was performed through a midline neck incision with cricotracheal anastomosis and sternohyoid muscle flap coverage.

On POD 7, bronchoscopy revealed a 3-mm region of separation and necrotic cartilage at the anterior anastomosis. A

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