Management of major hemorrhage during mediastinoscopy

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Objective: The management of major hemorrhage complicating mediastinoscopy is not well described. We reviewed our experience to determine the frequency, optimal management strategy, and outcome of these injuries.

Methods: A retrospective review of all mediastinoscopies performed at a single institution during a 12-year period (January 1990-January 2002) was performed. Major hemorrhage was defined as that requiring exploration for definitive control.

Results: During the study period, 3391 mediastinoscopies were performed. Fourteen patients (0.4%) experienced major hemorrhage. Most patients (12/14) had non-small cell lung cancer, and only 1 patient each underwent preoperative radiation, repeat mediastinoscopy, or extended mediastinoscopy. The most common biopsy site (4/14 cases) resulting in major hemorrhage was the lower right paratracheal region (level 4R), and the most frequently injured vessels were the azygos vein and the innominate and pulmonary arteries. Initial control of hemorrhage was achieved through packing in 93% (13/14), and the most common initial approach for exploration was sternotomy (8/14). Four patients underwent a planned pulmonary resection after definitive control of bleeding. The median amount of blood transfused was 2 units (range 0-18 units). Postoperative complications occurred in 2 of 14 patients (14%). There were no intraoperative deaths, but 1 patient died postoperatively (1/14, 7% mortality). The median postoperative length of stay was 6 days (range 1-19 days).

Conclusions: Major hemorrhage during mediastinoscopy is an uncommon but potentially morbid event. Initial control can usually be achieved through packing. Subsequent management presents a technical challenge but can result in minimal morbidity and mortality.

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Despite advances in imaging technology, mediastinoscopy remains a widely used procedure for the staging of bronchogenic carcinoma and the diagnosis of disease in the mediastinum. Originally devised and reported in 1959 by Carlens,¹ mediastinoscopy has been the subject of a number of studies that have looked at its sensitivity and specificity in the staging of bronchogenic carcinoma. It has been shown to be an extremely safe procedure with morbidity rates of 0.6% to 3.7% and mortality rates of 0% to 0.3% reported in several large series.²⁻¹¹ However, because mediastinoscopy involves dissection and biopsy of tissue in the superior mediastinum around the great vessels, there is always a risk of hemorrhage.

The definition of a “major” hemorrhage and the incidence of this complication are unclear. Review of the literature yields a variety of definitions, including bleeding greater than 500 mL, bleeding that requires a blood transfusion, and bleeding that requires exploration through a sternotomy or thoracotomy for control. Using the latter definition, the reported rates of major hemorrhage vary between 0% to 0.2% in most large series. Moreover, there is scant mention of the patient characteristics, intraoperative management, or sequelae of this uncommon but potentially lethal event.

We report the major bleeding complications seen during a 12-year period, which includes 3391 cervical mediastinoscopies at a single institution, to determine the risk factors and the frequency and types of injury. In addition, we review the intraoperative and postoperative management and the sequelae of these injuries to the patients.

Materials and Methods

A retrospective review of all cervical mediastinoscopies followed at the same setting by either thoracotomy or sternotomy performed by the Thoracic Surgery Service at Memorial Sloan-Kettering Cancer Center between January 1990 and January 2002 was performed. Operative reports from each of these patients were reviewed to identify major bleeding complications, defined as any bleeding that required an additional surgical incision for definitive control. Patients who experienced bleeding that was managed without requiring exploration were excluded. Patients who underwent a planned thoracotomy were considered to have had a major hemorrhage if packing remained in place and repair of an identified bleeding site was performed during exploration. An institutional review board-approved database containing patients identified in this manner was constructed.

Results

During the study period, 3391 cervical mediastinoscopies were performed, either alone or combined with a thoracic procedure. On the basis of our definition of major bleeding, we identified 14 patients who demonstrated a major hemorrhagic complication of mediastinoscopy. A number of patients with some degree of bleeding were successfully managed with packing and observation alone, thus avoiding exploration. There were 6 male and 8 female patients with a median age of 69 years (range 53-81 years). The indication for mediastinoscopy was non-small cell lung cancer (NSCLC) in 13 of 14 patients, of whom 7 demonstrated histologically proven NSCLC and 6 demonstrated a suspicious lung mass. Patients without a tissue diagnosis preoperatively were subsequently found to have bronchogenic carcinoma (5 NSCLC, 1 small cell carcinoma). In 4 of these patients, the diagnosis was established by mediastinoscopy. The remaining patient had a history of diffuse large cell lymphoma and a new, enlarging superior mediastinal mass. Although none of the patients underwent mediastinoscopy for a benign disease process (ie, sarcoidosis or other granulomatous disease), 64% of patients (9/14) who experienced

TABLE 1. Vascular injuries in relation to biopsy site (n = 14)

Lower right paratracheal (level 4R)	
Azygos vein	3
Superior vena cava	1
Subcarinal (level 7)	
Right main pulmonary artery	2
Bronchial artery	1
Upper right paratracheal (level 2R)	
Innominate artery	2
None found	1
Right tracheobronchial (level 10R)	
Right upper lobe segmental artery	2
Para-aortic (level 6)	
Innominate artery and vein, left internal carotid artery	1
Initial dissection	
Innominate artery	1

a major bleeding complication had a negative pathologic result from their mediastinoscopy.

Three patients had undergone prior therapy: induction chemotherapy with mitomycin, vinblastine, and cisplatin; systemic chemotherapy for diffuse large cell lymphoma; and chemotherapy and mantle radiation for B-cell lymphoma. The remaining 11 patients had received no other treatment before mediastinoscopy. Two patients underwent previous procedures in the mediastinum that included mediastinoscopy and coronary artery bypass grafting.

Injuries to specific vessels varied according to the locations of the biopsies performed (Table 1). The most common biopsy site associated with major hemorrhage was the lower right paratracheal region (level 4R) (4 patients). Patients sustained injury to a single vessel in 12 of 14 cases. In 1 patient who underwent an extended mediastinoscopy, the initial injury was to the innominate artery; subsequent injuries to the innominate vein and left internal carotid artery occurred during the attempt to repair the original injury. Another patient who presented with a possible innominate artery injury had no site of injury identified on exploration.

The initial maneuver in each case after injury was evident was to attempt to tamponade the bleeding through compression, which succeeded in controlling hemorrhage in 13 of 14 patients (93%). There was uncontrolled bleeding in only 1 patient who required immediate sternotomy. Packing with sterile gauze was the most common method of tamponade and was successful in all 9 patients in whom it was used. Direct compression of the injury site with the mediastinoscope was performed in 3 patients, 2 of whom had injuries to the innominate artery. Digital compression was used in the remaining 2 patients, including the 1 patient with uncontrolled bleeding. With continued local tamponade in place, patients underwent exploration.

The timing of and surgical approach for exploration were influenced by a number of factors, including the success of

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TABLE 2. Operative procedures and perioperative course

Median transfusions (units)	2 (0-18)
Median postoperative LOS (days)	6 (1-19)
Intraoperative mortalities	0 (0%)
In-hospital mortalities	1 (7%)
ICU admissions	3 (21%)
Other complications	
None	12 (86%)
Amaurosis fugax	1 (7%)
Cerebral ischemia	1 (7%)

LOS, Length of stay; ICU, intensive care unit.

tamponade at obtaining initial control, the site of injury, the hemodynamic status of the patient, the status of the mediastinum, and the intention to perform a concomitant pulmonary resection. Overall, sternotomy (8) was the most common initial incision, followed by right posterolateral thoracotomy (5). A review of the management strategies used in the setting of specific vascular injuries follows.

Azygos Vein

Of the 3 injuries in this series, 2 were managed with a standard right posterolateral thoracotomy, and 1 was managed with a sternotomy. The first patient underwent thoracotomy after an intraoperative chest x-ray film demonstrated a right hemothorax. The second patient underwent thoracotomy for a planned right lower lobectomy after control of the hemorrhage. The third patient underwent sternotomy on the basis of the surgeon's decision for immediate exploration and repair.

Innominate Artery

These 5 injuries (4 confirmed and 1 not confirmed) were approached through a median sternotomy in all but 1 patient, allowing for repair of the artery in each instance. The 1 patient who did not undergo a sternotomy for exposure had undergone a previous CABG procedure, making an expedient sternotomy difficult. This patient's innominate artery was exposed, instead, by resection of the manubrium.

Right Pulmonary Artery

There were 2 types of injuries to the right pulmonary artery. Two patients had injuries to 1 of the segmental branches to the right upper lobe. After compression, with packing in place, a posterolateral thoracotomy was used to ligate the bleeding vessel and perform a lobectomy. Two patients sustained injuries to the posterior aspect of the right main pulmonary artery. A sternotomy was the initial incision used for exploration, and in both cases an anterolateral thoracotomy incision was added. The pericardium was widely incised superiorly back to the level of the atria, and the right pleural space was opened. The azygos vein was

ligated and divided, and the superior vena cava and ascending aorta were retracted away from one another to expose the right main pulmonary artery. The origin of the right main pulmonary artery was controlled with direct compression with a sponge stick, and primary repair was performed. Cardiopulmonary bypass was not required.

Superior Vena Cava

One patient sustained an injury to a small posterior tributary of the superior vena cava. This patient was initially explored through a sternotomy because of a concern that the injury was incompletely tamponaded. When a significant hemothorax was encountered, indicating a more posterior injury, an additional right anterolateral thoracotomy through the fourth interspace was subsequently performed. This enabled repair of the injury, evacuation of the hemothorax, and additional biopsies of mediastinal lymph nodes.

Bronchial Artery

One patient demonstrated bleeding from a bronchial artery during biopsies in the subcarinal space. Because all of the nodes tested negative for malignancy and the hemorrhage was well controlled with the packing in place, the patient was explored through a thoracotomy. The subcarinal space was easily entered, and the artery was clipped uneventfully. The patient then went on to undergo an upper lobectomy as planned.

In all but 1 patient, control of hemorrhage was achieved through primary repair or ligation of the affected vessels. In the other patient, no evidence of ongoing bleeding was found after a thorough exploration; the incision was closed, and the patient was carefully observed. Most patients (10/14) underwent additional procedures at the time of exploration. Six patients had further biopsies taken within the mediastinum. Four patients underwent anatomic pulmonary resections (all lobectomies, 1 with a chest wall resection). In 3 of these patients, the resections were a planned part of the procedure before mediastinoscopy.

Most patients (93%) recovered with little or no morbidity. Only 3 patients required admission to the intensive care unit postoperatively (Table 2). The median number of units of packed red blood cells transfused during the entire hospitalization was 2 (range 0-18 units). Four patients received no transfusions. There were no intraoperative deaths and only 1 in-hospital death (1/14, 7%). This patient, who had an injury during extended mediastinoscopy, had evidence of cerebral ischemia and previously undetected brain metastases postoperatively, and the family elected to withdraw care. One other patient experienced a postoperative complication, amaurosis fugax, for a morbidity rate of 14%. The remaining patients were discharged without complication. Overall, the median length of stay was 6 days (range 1-19 days).

TABLE 3. Reported complication rates of mediastinoscopy

Author	Year	N	Major bleed (%)	Morbidity (%)	Mortality (%)
Jepsen ²	1966	4134	4 (0.1)	39 (0.9)	0 (0)
Ashbaugh ³	1970	9543	11 (0.2)*	149 (1.6)	9 (0.09)
Foster et al ⁴	1972	3742	6 (0.2)	60 (1.6)	3 (0.08)
Kliems and Savic ⁵	1979	600	2 (0.3)	24 (3.7)	1 (0.2)
Luke et al ⁶	1986	1000	2 (0.2)	23 (2.3)	0 (0)
Puhakka ⁷	1989	2021	4 (0.2)	47 (2.3)	0 (0)
Cybulshky and Bennett ⁸	1994	1015	0 (0)	14 (1.4)	0 (0)
Hammoud et al ⁹	1999	2137	2 (0.1)	12 (0.6)	4 (0.2)
Urschel ¹⁰	2000	324	2 (0.6)	NR	1 (0.3)

NR, Not reported.

*Based on 6490 patients.

Discussion

Cervical mediastinoscopy has been shown to be a safe and effective diagnostic procedure.²⁻¹¹ Although there are a number of known complications of mediastinoscopy that include hemorrhage, pneumothorax, nerve injury (recurrent or phrenic), esophageal or tracheal injury, wound infection, and other sequelae of general anesthesia (cardiac ischemia, arrhythmia, or respiratory insufficiency), review of the largest single-institution and collected series published in the last 35 years (Table 3) shows that the reported morbidity rates directly attributed to mediastinoscopy range from 0.6% to 3.7%. Similarly, the overall mortality rate varies from 0% to 0.2% with several authors reporting no mortalities after mediastinoscopy.^{2,6-8} However, because injury to major vascular structures may prove fatal, hemorrhage remains the most feared complication. Despite this, there is little written in the literature that examines the nature of major hemorrhagic complications of mediastinoscopy or reviews management of this uncommon but difficult problem.

The largest reported series of mediastinoscopies have not used a uniform definition of “major hemorrhage.” Most authors reported bleeding complications that include “moderate” bleeding, hemorrhage requiring thoracotomy, and injury to specific vessels, such as the pulmonary artery or azygos vein. Others documented major hemorrhage occurring when the volume of blood lost exceeded a predetermined number, such as 500 cc. We chose to define major hemorrhage as any bleeding that ultimately required additional surgical exploration for definitive control, because these situations present an intraoperative challenge and can result in a fatal outcome. Using this definition, the frequency of major bleeding complications reported to date range from 0% to 0.3% (Table 3). The current study demonstrated a major hemorrhage rate of 0.4% (14/3391), confirming that this is an uncommon event. However, with the exception of 1 report,⁸ every large series included patients

who have experienced this complication, showing that even in the most experienced hands, major hemorrhage can occur during mediastinoscopy. Moreover, in at least 2 series there were intraoperative or perioperative deaths as a direct result of episodes of major bleeding, further emphasizing the potentially devastating consequences of such injuries.

Prior reviews have not addressed the risk factors predisposing patients to a major hemorrhagic complication during mediastinoscopy.^{7,8,17,18} There are a number of factors that may potentially increase the risk of a major bleeding complication in certain patients by creating an abnormal mediastinum. These include induction therapy, prior external beam radiotherapy to the mediastinum, prior surgical procedure in the mediastinum, or reoperative mediastinoscopy. We did not identify any patient characteristics that clearly predicted a major bleeding event. Eleven of the 14 patients had no prior therapy or mediastinoscopy. Only 1 of our patients underwent a reoperative procedure after both prior mediastinoscopy and induction chemotherapy for NSCLC. A few small series have reported no hemorrhagic complications resulting from reoperative mediastinoscopy.¹⁷⁻²¹ Similarly, only 1 of our patients underwent an extended mediastinoscopy. Ginsberg and Rice^{12,13} previously reported only 1 injury to the innominate artery in more than 300 extended mediastinoscopies, and others have reported similar results as well.¹⁴⁻¹⁶

Regardless of the presence of clear risk factors for major bleeding during mediastinoscopy, preventative measures are paramount. The operating surgeon must be familiar with the anatomic relationships within the mediastinum, performing careful dissection to expose the area of interest and surrounding structures. When in doubt, needle aspiration should be performed to avoid direct biopsy of vessels. Portions of lymph nodes should be enucleated, and excessive traction should be avoided. If the mediastinum has been distorted by prior therapy so that anatomic structures cannot

be discerned with confidence, the procedure should be aborted.

Despite following all of these measures discussed, every surgeon encounters some degree of hemorrhage during mediastinoscopy. Almost all can be managed with conservative measures and do not require exploration. In the event that there is major bleeding, the initial maneuver should be an attempt to control the hemorrhage with local compression. The most common and effective means of accomplishing this is through gauze packing of the wound with either sterile 4 × 8 gauze or vaginal packing. For most injuries, this will provide temporary control during which the patient can be resuscitated and preparations made for further surgical exploration. When a systemic artery is injured, digital compression or tamponade with the mediastinoscope may be necessary to achieve control. If local measures fail to control bleeding or if the patient demonstrates persistent hemodynamic instability despite volume resuscitation, immediate surgical exploration through a median sternotomy should be performed.

Decisions regarding surgical exploration for definitive control of bleeding versus continued conservative management need to be made by the operating surgeon on a case-by-case basis. In our series, most patients underwent exploration after 1 or more attempts at hemostasis with packing alone over a period of 20 to 45 minutes each. The most appropriate incision for exposure should depend primarily on the site of injury and the status of the mediastinum. In patients whose mediastinum is not scarred (ie, no prior sternotomy) and whose injury is unknown or involves the innominate artery or anterior surface of the superior vena cava, a median sternotomy provides excellent and rapid exposure. Injuries to the azygos vein or posterior aspect of the superior vena cava are more difficult to access through a sternotomy but can be managed with this approach. Once definitive control of bleeding has occurred, anatomic pulmonary resection may be performed, although lower lobectomy is more challenging technically. Alternatively, if patients are hemodynamically stable and are believed to have an azygos vein, posterior superior vena cava, or segmental pulmonary artery injury, a standard right posterolateral thoracotomy provides excellent exposure for both repair of the injury and pulmonary resection. Packing should be left in place while single lung ventilation is established and the patient is repositioned.

Patients who have undergone a prior sternotomy present a dilemma in the event of a significant hemorrhage. Access to the superior and middle mediastinum cannot be achieved quickly through a sternotomy because of the risk of cardiac injury. If the injury was sustained in the lower paratracheal or subcarinal space, the patient should be turned and explored through a right thoracotomy. If the injury is believed to be at the level of the innominate vessels, then exploration

can be performed with careful partial upper sternal split or resection. Last, a reoperative sternotomy may be performed with cardiopulmonary bypass on standby.

An alternative management strategy, reported previously by Urschel,¹⁰ is the use of an extended period of packing. Applicable in situations in which hemorrhage is controlled with packing and the mediastinum is distorted by prior therapy, surgery, or extensive, unresectable disease, packing may be left in place while the patient leaves the operating room, intubated and sedated. The following day, the patient returns to the operating room for removal of packing and reexploration of the wound.

Another situation that is particularly challenging technically is injury to the right main pulmonary artery. Regardless of the initial incision made, sternotomy or thoracotomy, exposure and repair of this injury is technically difficult. If a sternotomy has been performed, we have found that extending the incision to an anterolateral thoracotomy in the fourth intercostal space creating a hemiclamshell incision to be extremely helpful. The pericardium should then be widely incised superiorly back to the level of the atria. The right pleural space is opened, and the azygos vein ligated and divided to allow exposure of the right pulmonary artery distally. The superior vena cava and the ascending aorta should be retracted to the patient's right and left, respectively, to facilitate exposure to the pulmonary artery. Proximal control of the right main pulmonary artery can be achieved with direct compression (usually with a sponge stick) because the site of the injury is on the posterior aspect of the artery immediately distal to its origin. The pulmonary arterial injury is then repaired primarily. Although this can be performed without cardiopulmonary bypass, one should not hesitate to use it in the event that visualization is poor or repair cannot be performed without ongoing blood loss.

Conclusion

Although major hemorrhage during mediastinoscopy is an uncommon event, it remains a potentially morbid and mortal complication. Avoidance is enhanced by knowledge of the anatomic relationships in the mediastinum, careful dissection, and operator experience. If major bleeding is encountered, initial control in virtually all instances can be achieved through packing. Successful management requires urgent, well-coordinated care. The surgical approach used to definitively repair the injury should be based primarily on the site of injury and the status of the mediastinum and, to a lesser degree, on the pathologic result of the biopsy and the intention to perform a concomitant pulmonary resection.

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