



Preoperative embolization to reduce morbidity and mortality in hypervascular mediastinal tumor surgery

Hipervasküler mediastinal tümör cerrahisinde morbidite ve mortalitenin azaltılması için ameliyat öncesi embolizasyon

Bülent Aydemir¹, Sinan Şahin², Muharrem Çelik¹, Tamer Okay¹

¹Department of Thoracic Surgery, Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital, İstanbul, Turkey

²Department of Radiology, Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital, İstanbul, Turkey

ABSTRACT

Background: This study aims to describe the preoperative embolization procedures to reduce morbidity and mortality in hypervascular mediastinal tumor surgery and to evaluate the efficacy and safety of these procedures.

Methods: Between January 2008 and December 2014, nine patients (5 males, 4 females; mean age 37 years; range 17 to 48 years) with mediastinal tumors underwent preoperative embolization of the feeding arteries before surgery. All patients received a combination of polyvinyl alcohol particles (300-1200 µm) in combination with coils. The criterion for the embolization effectiveness was to reduce intraoperative hemorrhage.

Results: In eight patients, embolization was successfully completed without any complication. The feeding vessels of each tumor were occluded. No symptomatic complications related to embolization were observed. Tumors were totally removed in eight patients. Embolization clearly reduced the severity of bleeding during surgery, lowered the surgical risks due to blood loss, and reduced the difficulty of tumor resections. No intra- or postoperative complication was seen.

Conclusion: Our study highlights the importance and essence of preoperative embolization to control bleeding during surgery, particularly in large-size tumor resections with an excessive vascular nature. Based on our study results, we suggest interventional embolization as a prerequisite before hypervascular mediastinal tumor surgery to reduce morbidity and mortality.

Keywords: Castleman disease; mediastinal tumor; paraganglioma; preoperative embolization.

ÖZ

Amaç: Bu çalışmada hipervasküler mediastinal tümör cerrahisinde morbidite ve mortaliteyi azaltmak için ameliyat öncesi embolizasyon işlemleri tanımlandı ve bu işlemlerin etkinliği ve güvenliği değerlendirildi.

Çalışma planı: Ocak 2008 - Aralık 2014 tarihleri arasında mediastinal tümürlü dokuz hastaya (5 erkek, 4 kadın; ort. yaş 37; dağılım 17-48 yıl) ameliyat öncesinde besleyici arterlere embolizasyon yapıldı. Tüm hastalara polivinil alkol partikülleri (300-1200 µm) ve bobin kombinasyonunu uygulandı. Embolizasyonun etkinliği için kriter, ameliyat sırasındaki kanama miktarının azalması idi.

Bulgular: Sekiz hastada embolizasyon herhangi bir komplikasyon olmadan başarılı bir şekilde tamamlandı. Her bir tümörü besleyen damarlar kapatıldı. Embolizasyon ile ilişkili semptomatik komplikasyon gözlenmedi. Sekiz hastada tümörler tamamen çıkarıldı. Embolizasyon, ameliyat sırasında kanama şiddetini belirgin düzeyde azalttı; kan kaybı ile ilişkili ameliyat risklerini düşürdü ve tümör rezeksiyonlarının güçlüğü azalttı. Ameliyat sırasında ve sonrasında herhangi bir komplikasyon görülmüdü.

Sonuç: Çalışmamız, özellikle aşırı vasküler yapılı büyük çaplı tümör rezeksiyonlarında, ameliyat sırasında kanama kontrolünü sağlamak amacı ile ameliyat öncesi embolizasyonunun önemini ve gerekliliğini göstermektedir. Çalışma sonuçlarımıza göre, morbidite ve mortalitenin azaltılması için hipervasküler mediastinal tümör ameliyatlarından önce girişimsel embolizasyonun uygulanmasını önermekteyiz.

Anahtar sözcükler: Castleman hastalığı; mediastinal tümör; paragangliom; ameliyat öncesi embolizasyon.

Received: September 27, 2016 Accepted: October 18, 2016

Correspondence: Bülent Aydemir, MD. Dr. Siyami Ersek Göğüs Kalp ve Damar Cerrahisi Eğitim ve Araştırma Hastanesi, Göğüs Cerrahisi Kliniği, 34668 Üsküdar, İstanbul, Turkey. Tel: +90 505 - 621 60 60 e-mail: aydemirb@hotmail.com

Cite this article as:

Aydemir B, Şahin S, Çelik M, Okay T. Preoperative embolization to reduce morbidity and mortality in hypervascular mediastinal tumor surgery. Turk Gogus Kalp Dama 2017;25(4):627-32.

Mediastinal tumors tend to develop in different types, sizes, and locations with an unknown etiology in most of the cases. Patients do not experience any noticeable symptoms, until the tumor grows and starts pressuring on other organs and, consequently, the symptoms become noticeably for the patient. These tumors should be treated in a timely manner, as they may grow in a larger size and may carry a high risk for the patient. Large thoracic mediastinal tumors have a rich blood supply derived from multiple arteries.^[1]

Embolization is used for several purposes including to decrease the tumor size before excisional surgery, to allow surgery by reducing intraoperative hemorrhage, to manage acute hemorrhage, and for palliative care and tumor reduction.^[2] Embolization of large hypervascular mediastinal tumors is considered critical in tumor resection, as it mainly decreases blood loss during surgery, provides a clearer operative field for the surgeon, and reduces the associated morbidities.^[3,4]

In the present study, we present our experience of preoperative embolization in patients with mediastinal

tumors with an excessive vascular nature and to evaluate the efficacy and safety of the embolization procedures.

PATIENTS AND METHODS

Between January 2008 and December 2014, a total of 120 patients underwent mediastinal tumor resections in our clinic. Of these patients, nine (5 males, 4 females; mean age 37 years; range 17 to 48 years) received preoperative tumor embolization to control the main feeding arteries. Four patients had an uncompleted surgical resection due to massive bleeding prior to their arrival to our clinic for re-evaluation. In two patients, thoracic computed tomography (CT) images showed large vessel branches. Three patients have a large mediastinal tumor indicating a high risk for an excessive vascular nature.

All patients underwent routine biochemical tests, radiographs, pulmonary function tests, and CT. Based on the CT scans, angiography was carried out to identify the rich vascularization of the tumors in each case. Tumor vascularization on the arterial angiogram

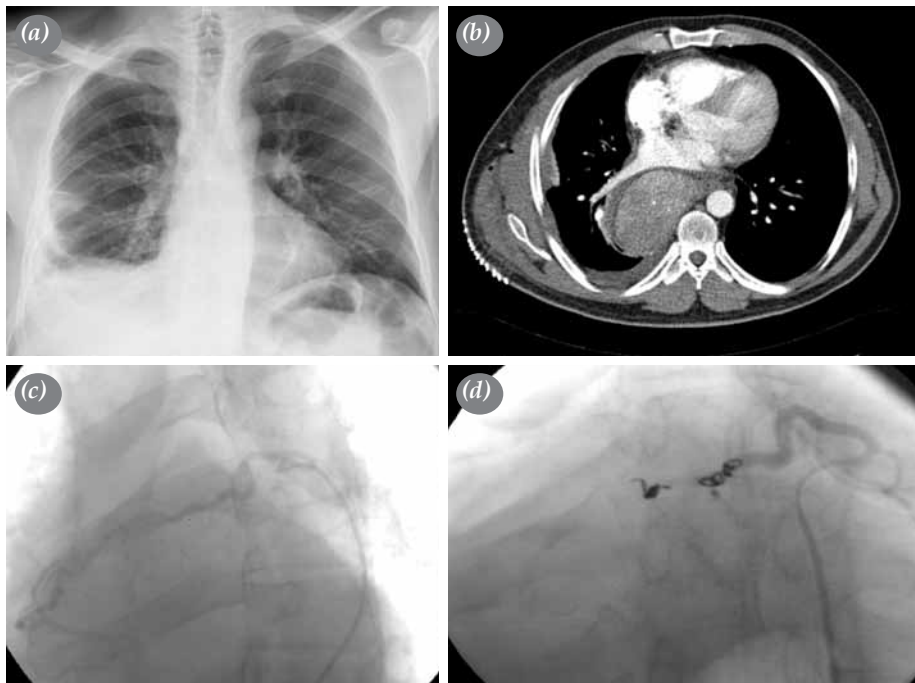


Figure 1. (a) A posteroanterior chest X-ray showing thickening of right minor fissure, blunt right costophrenic recess, linear densities at right lower zone, and closed right cardiophrenic angle. (b) A contrast-enhanced computed tomography scan showing a heterogeneous soft tissue mass at right paravertebral region, high density effusion at right posterior and at the right minor fissure. (c) Digital subtraction angiography showing a major feeding artery and its multiple branches feeding the mass. (d) No contrast enhancement was seen after coil and particle embolization (complete embolization) of the main feeding artery.

was defined as moderate for three patients and as extensive for six patients. Multiple feeding vessel embolization procedures under local anesthesia in a single session were performed. All catheterizations were performed via a transfemoral approach by the Seldinger technique. A 6F to 8F catheters were used. The suspected feeding arteries were delineated and followed by super selective catheterization one by one. Various particle embolization agents (Contour embolization particles, Boston Scientific, Natick, MA, USA; Embosphere, Biosphere Medical, France; Embozone, San Antonio, TX, USA) with a diameter ranging from 300 to 1200 μm were injected using an appropriate contrast medium mixture. Embolization started with small-sized particles and followed by larger-sized ones to occlude capillary bed and feeding arteries. After complete occlusion was achieved, one or more 0.018-inch fibered platinum microcoils (Vortex, Boston Scientific, France; Tornado, Cook Inc., Bloomington, IN) were deployed at the proximal part of the main artery to prevent recanalization until

the operation. Ranging from 48 h to five days after embolization, the patients underwent mediastinal tumor resection. Total excision of anterior mediastinal tumors was performed using sternotomy, while the others were performed through posterolateral thoracotomy.

The study protocol was approved by the Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital Ethics Committee. A written informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki.

RESULTS

Embolization was completed in eight patients (Figure 1), while partial embolization was performed in one patient. The reason for partial embolization was the sharp angulation of one of the feeding arteries (Figure 2).

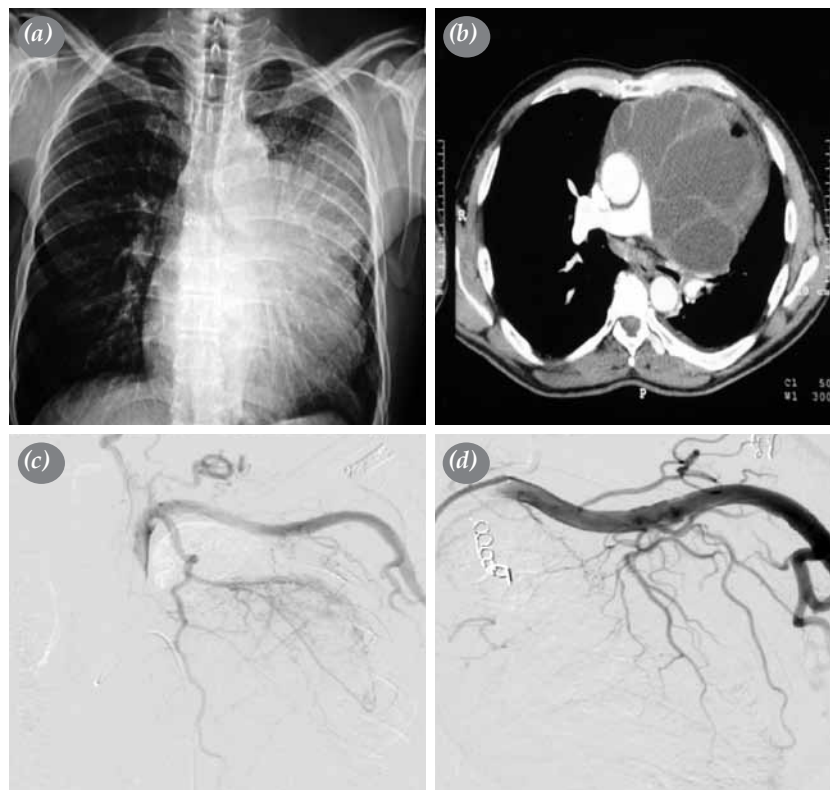


Figure 2. (a) A posteroanterior chest X-ray showing a left mid-upper zone mass. (b) A contrast-enhanced computed tomography scan showing multi-septated heterogeneous mediastinal mass occupying the anterior mediastinal space and extending to left anterolateral region. (c) Digital subtraction angiography showing multiple tortuous feeding arteries originating from left subclavian artery. (d) After coil and particle embolization of the main feeding arteries, minor feeding arteries became more prominent.

Table 1. Embolization procedure

Patient	Embolization material		Embolization	Types of veins embolized	Complications
	Catheterization	Coil			
1	2×(700-900 µm) PVA	2×(4×70 mm)	Complete	Left & right IMA	Pain
2	500-700 µm MSEA 900-1200 µm MSEA	3×30 mm 4×30 mm	Complete	Right branchial artery	None
3	355-500 µm PVA 700-900 µm PVA 900-1200 µm PVA	4×70 mm	Partial	IMA subclavian artery branches	None
4	300-500 µm MSEA 500-700 µm MSEA 700-900 µm MSEA	2×(6×60 mm)	Complete	Left 8 th intercostal artery	High fever and pain
5	300-500 µm MSEA 500-700 µm MSEA	3×30 mm 4×30 mm	Complete	Right IMA	Pain
6	355-500 µm PVA	2×(4×40 mm) complex	Complete	Right branchial artery	None
7	300-500 µm MSEA 500-700 µm MSEA	4×40 mm	Complete	Right branchial artery	None
8	400 µm PVA	2×(6×60 mm)	Complete	Right 9 th intercostal artery	Pain
9	500-700 µm MSEA 700-900 µm MSEA	5×60 mm 6×60 mm	Complete	Right 8 th intercostal artery	None

PVA: Polyvinyl Alcohol; MSEA: Microspheric embolizing agent; IMA: Internal mammary artery.

Table 2. Clinical characteristic of patients

No	Age/Gender	Diagnosis	Side	Histology	Symptoms	Size (cm)	Survival
1	20/M	Teratoma	Anterior mediastinum	Benign	Chest pain, cough	10×13×8	Alive
2	43/M	Castleman disease	Middle mediastinum	Benign	Shortness of breath, lassitude	8×7×11	Alive
3	48/M	Teratoma	Anterior mediastinum	Benign	Shortness of breath, chest pain, cough	15×14×9	Alive
4	45/F	Schwannoma	Post mediastinum	Benign	By chance: Taken X-ray for flu	13×8×5 15×13×8	Alive
5	17/F	Teratoma	Anterior mediastinum	Benign	By chance: High rate in sedimentation and arthralgia	10×6×6 3×2×2	Alive
6	34/F	Castleman disease	Middle mediastinum	Benign	By chance: Lumbar herniated disc operation	7×7×3.5	Alive
7	37/F	Paraganglioma	Middle mediastinum	Benign	Shortness of breath, chest pain, cough	5×4×3	Alive
8	45/M	Schwannoma	Post mediastinum	Benign	Back pain	10×10×6	Alive
9	45/M	Schwannoma	Post mediastinum	Benign	By chance	5×6×6	Alive

The detailed information for each procedure is summarized in Table 1. In nine embolization cases, a total of 12 arteries were embolized. The most common artery which was embolized was the right branchial artery. The complaints following embolization were often mild, while only four patients recorded pain. The detailed clinical characteristics of patients are summarized in Table 2. The lesions were located at the anterior mediastinum (n=3), at the middle mediastinum (n=3), and at the posterior mediastinum (n=3). There were three cases of teratoma, three cases of Schwannoma, two cases of Castleman disease, and one case of paraganglioma. The mean tumor diameter was 9.2 (range, 3 to 15) cm.

The removal of the tumors was carried out with minimal blood loss with clearer operative field and

shorter length of surgery in patients undergoing preoperative embolization. Four patients did not receive any intra- or postoperative blood transfusion, while two patients received two units and the other two patients received one unit of blood transfusion. However, one patient with partial embolization received a total of 12 units of blood transfusion. The mean length of stay in the hospital following surgery was 6.2 (range, 4 to 10) days.

DISCUSSION

The first arterial transcarotid paraffin and petroleum embolization was reported by Dawbain in 1904 with the aim of hemorrhage management.^[5] In 1960, Luessenhop and Spence introduced the artificial embolization technique, which was methylmethacrylate

embolization in the carotid artery to avoid arteriovenous malformations.^[6] In 1972, Rösch *et al.*^[7] for the first time, performed artery embolization to treat uterine myomata.^[7] In 1975, Gianturco *et al.*^[8] used wool coils for the first time. In 1991, Guglielmi *et al.*^[9] detachable coil (GDC) embolization was introduced as an alternative method for the treatment of selected aneurysm patients. Since then, embolization is a common and, at the same time, popular procedure used in various surgeries.

Preoperative embolization of large mediastinal tumors is considered critical in tumor resection, as in most cases, large mediastinal tumors have a rich blood supply derived from multiple arteries. Surgery of highly vascular thoracic sarcomas can be risky, as it is amplified by potential hemorrhage and poor vascular control.^[10] In addition, the most optimal treatment choice for paragangliomas is surgical resection following preoperative embolization due to their high vascularity.^[11] Although Castleman disease is unusual, critical bleeding is often experienced during surgery due to the hypervascular nature of the tumor.^[12,13]

There are many cases reported in the literature showing that the surgeons were unable to complete tumor resection operations due to massive bleeding.^[10,14,15] Neuroendocrine tumors are highly vascular in nature, and many patients experience intraoperative hemorrhagic complications.^[16] Morandi *et al.*^[14] reported that, during right thoracotomy, the mass which was reported as a hemangiopericytoma was highly vascularized and massive bleeding from the tumor tissue occurred during the dissection. Therefore, they were only able to perform a biopsy procedure and, then, planned arterial embolization.

Furthermore, there are several cases which resulted in mortality due to severe bleeding during tumor resection. Aydemir *et al.*^[15] reported a patient with a giant (15 cm) solitary fibrous tumor supplied by multiple intercostal arteries and an aberrant artery branched off the celiac trunk in his subdiaphragmatic region in whom embolization failed due to a high number of arteries. The authors decided to control possible bleeding by inducing total circulatory arrest through cardiopulmonary bypass. Although cardiopulmonary bypass was completed successfully, the patient died due to massive bleeding.

In addition, in some cases, the aberrant vascular pedicles spread through the pleura, where the tumor is attached and fed. In such cases, intraoperative bleeding would not originate from one site, but from many sites on the pleura surface. Thus, it would become impossible to control the massive bleeding

and continue surgery. For such cases, we believe that embolization is a must.

In conclusion, complete embolization before hypervascular mediastinal tumor surgery is necessary to reduce intraoperative bleeding effectively, to provide a clearer operative field for the surgeon, and to allow a complete surgical resection. It also lowers the mortality risk. Based on our study results, it is evident that preoperative embolization is a safe, beneficial, and valuable preoperative adjunct in the treatment of large thoracic mediastinal tumors with an excessive vascular nature. We suggest that there is also a high need of three-phase computed tomography for the final evaluation and highly recommend angiography of all massive chest tumors before any scheduled operations.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

REFERENCES

1. Liu FY, Wang MQ, Duan F, Wang ZJ. Combined embolization and surgical resection of a giant mediastinal tumor. *Thorac Cardiovasc Surg* 2014;62:265-9.
2. Krauel L, Albert A, Mora J, Sola T, Cruz O, Mortera C, *et al.* Use of angioembolization as an effective technique for the management of pediatric solid tumors. *J Pediatr Surg* 2009;44:1848-55.
3. Paul S, Jain SH, Gallegos RP, Aranki SF, Bueno R. Functional paraganglioma of the middle mediastinum. *Ann Thorac Surg* 2007;83:14-6.
4. Andrade CF, Camargo SM, Zanchet M, Felicetti JC, Cardoso PF. Nonfunctioning paraganglioma of the aortopulmonary window. *Ann Thorac Surg* 2003;75:1950-1.
5. Alexander LF, Ward BA. The history of endovascular therapy. *Neurosurg Clin N Am* 1994;5:383-91.
6. Luessenhop AJ, Spence WT. Artificial embolization of cerebral arteries. Report of use in a case of arteriovenous malformation. *J Am Med Assoc* 1960;172:1153-5.
7. Rösch J, Dotter CT, Brown MJ. Selective arterial embolization. A new method for control of acute gastrointestinal bleeding. *Radiology* 1972;102:303-6.
8. Gianturco C, Anderson JH, Wallace S. Mechanical devices for arterial occlusion. *Am J Roentgenol Radium Ther Nucl Med* 1975;124:428-35.
9. Guglielmi G, Viñuela F, Sepetka I, Macellari V. Electrothrombosis of saccular aneurysms via endovascular approach. Part 1: Electrochemical basis, technique, and experimental results. *J Neurosurg* 1991;75:1-7.
10. Puma F, Cardini CL, Passalacqua G, Ragusa M. Preoperative embolization in surgical management of giant thoracic

- sarcomas. *Eur J Cardiothorac Surg* 2008;33:127-9.
11. White JB, Link MJ, Cloft HJ. Endovascular embolization of paragangliomas: A safe adjuvant to treatment. *J Vasc Interv Neurol* 2008;1:37-41.
 12. Amano Y, Takai D, Ohishi N, Shinozaki-Ushiku A, Fukayama M, Akahane M, et al. Successful Treatment of Mediastinal Unicentric Castleman's Disease Using Video-Assisted Thoracoscopic Surgery with Preoperative Embolization. *Case Rep Med* 2013;2013:354507.
 13. Aydemir B, Okay T, Imamoglu O, Sahin S, Dogusoy I. Preoperative embolization in mediastinal Castleman's disease. *Thorac Cardiovasc Surg* 2010;58:496-8.
 14. Morandi U, Stefani A, De Santis M, Paci, Lodi R. Preoperative Embolization in Surgical Treatment of Mediastinal Hemangiopericytoma. *Ann Thorac Surg* 2000;69:937-9.
 15. Aydemir B, Celik S, Okay T, Dogusoy I. Intrathoracic giant solitary fibrous tumor. *Am J Case Rep* 2013;14:91-3.
 16. O'Riordain DS, Young WFJr, Grant CS, Carney JA, van Heerden JA. Clinical spectrum and outcome of functional extraadrenal paraganglioma. *World J Surg* 1996;20:916-22.