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Balloon embolization of bronchial artery: a new technique in massive hemoptysis

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ABSTRACT

Aims: Massive hemoptysis, characterized by severe respiratory bleeding, requires immediate medical attention due to its high mortality rate. We described our experience with the parachute balloon embolization procedure for life-threatening massive hemoptysis in this article.

Methods: The study was planned for 14 patients who presented with massive hemoptysis, had a high surgical risk, and failed medical and bronchoscopic treatment. The bleeding focus was embolized by placing the balloon, which was cut in half and separated from its shaft, using the new parachute technique.

Results: Hemorrhage was effectively controlled in all individuals. One patient died during the in hospital follow-up. During the 6-month follow-up period, there were no instances of repeated bleeding detected in the 13 patients.

Conclusion: The use of balloon embolization using the parachute approach can be an effective and safe bail out treatment option for those with severe hemoptysis. Furthermore, this technique may facilitate the development of new treatment modalities and the creation of novel devices in the future.

Keywords: Massive hemoptysis, artery embolization, life threatening hemoptysis, bronchial artery

INTRODUCTION

Hemoptysis is defined as the expulsion of blood originating from under the vocal cords, that is, from the lower airways.[1,2] Different classifications have been made according to the amount of bleeding. The definition of large hemoptysis is a topic of ongoing discussion, with considerable hemoptysis often defined as any amount ranging from 100 to 1,000 ml ml/day.[3] Massive hemoptysis is a critical medical condition characterized by significant bleeding from the respiratory tract, which necessitates urgent intervention due to its substantial risk of fatality. If untreated, it has a high mortality and morbidity rate. The main cause of death in patients with massive hemoptysis is not bleeding, but asphyxia secondary to bleeding. In contrast to hemorrhage occurring in other circumstances, a limited quantity of blood has the potential to quickly flood the respiratory passages, so impeding the process of oxygenation and breathing.[4] This obstruction might result in hypoxia and subsequent circulatory failure. Approximately 15% of hemoptysis cases are classified as life-threatening hemoptysis and require immediate life-saving intervention.[5] Approaches to life-threatening hemoptysis include medical treatment, bronchoscopic approach, and bronchial artery embolization (BAE) and surgical resection treatments.[6] Since the 1970s, endovascular intervention therapy has preceded surgical treatment in experienced centers, as it has a lower mortality and morbidity rate compared to surgical treatment.[6,7] In our article, we presented our experience with a new balloon embolization method, which we call the parachute technique, in the treatment of life-threatening massive hemoptysis.

METHODS

Ethics

The study was conducted with the permission of Fırat University Non-interventional Researches Ethics Committee (Date: 31.12.2020, Descision No: 2020/17-36). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Study Population

The study was conducted on patients with massive hemoptysis who were admitted to our hospital between January 2018 and December 2020. Bronchial artery embolization was planned for patients who were unsuccessful in medical treatment and bronchoscopic treatment and who had a high surgical risk. 14 patients meeting these criteria were included in the study.

Diagnostic Tools

Emergency computed tomography (CT) angiography and bronchoscopy are used to identify bleeding foci in patients. CT angiography is a high-sensitivity imaging modality of choice to evaluate the lung parenchyma, the number and anatomy of bronchial arteries, and to determine the localization of bronchial artery bleeding (**Figure 1**). Additionally, the identification of bleeding foci was accomplished with the use of bronchoscopy, which served both diagnostic and potentially therapeutic purposes.

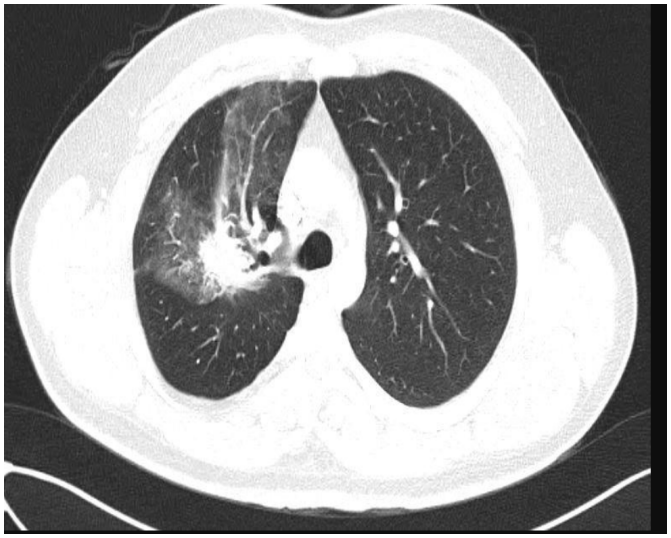

Figure 1. Computed tomography showing bleeding in the middle zone of the right lung

Pulmonary Intervention

BAE was performed in all cases by entering through the femoral artery. Diagnostic angiography of the aortic arch and descending thoracic aorta was performed to view the bronchial artery by advancing a 5-F multihole catheter (Pigtail Cook, Bloomington, Indiana) over a 0.035-inch hydrophilic guidewire (Terumo, Tokyo, Japan) into the thoracic aorta. Afterwards, the artery was engaged with 7F Amplatz Left or Amplatz right 2 catheters. The embolization process was planned with the method we call the parachute technique. Balloon diameters between 2.0 and 4.0 were selected depending on the target artery (Solaris, medtronic). Ballons were inflated to a pressure of 4 atm. Downloaded after 30 seconds. Then the balloon part was separated by cutting from the distal shaft part. The balloon was cut in half (**Figure 2**). The two formed parts (the main balloon shaft and the cut distal part of the balloon) were separately loaded on the floppy wire with the cut side of the balloon opposite to the flow direction (parachute effect). Using 0.014 wire, it was attempted to be moved to the lesion region (**Figure 3**). The cut shaft of the balloon was pushed with its half, and the material to be left was stabilized by keeping the balloon shaft fixed to the proximal bronchial artery. Because of the unidirectional artery flow, the balloon was expanded slightly and positioned in the lesion area as a result. And the wire was pulled slowly and retracted (**Figure 4**). The balloon shaft was then pulled back from the remaining piece. If satisfactory embolization was not achieved, the same process was repeated in the bleeding pulmonary artery branch. Arterial bleeding was stopped with controlled iatrogenic embolization.

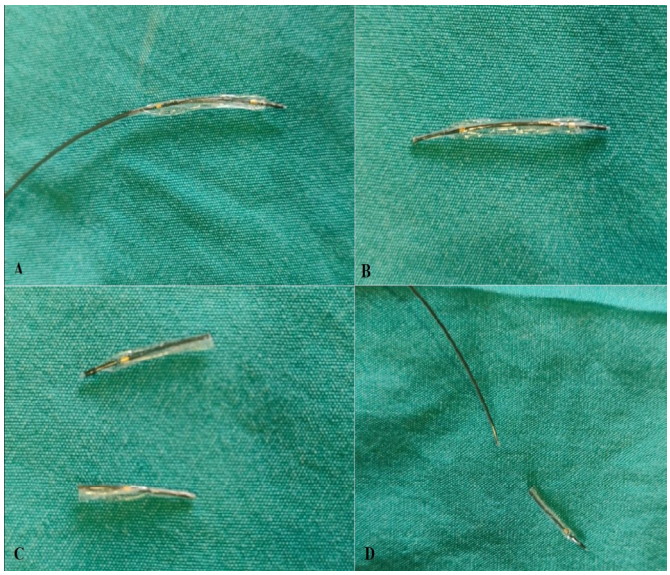

Figure 2. A. Ballons were inflated to a pressure of 4 atm. Downloaded after 30 seconds, **B.** Then the balloon part was separated by cutting from the distal shaft part, **C.** The balloon was cut in half, **D.** The main balloon shaft and the cut distal part of the balloon were prepared separately load on the floppy wire with the cut side of the balloon opposite to the flow direction (parachute effect)

Figure 3. The balloon main shaft and the cut balloon distal part are loaded on 0.14 wire to be transported to the target artery

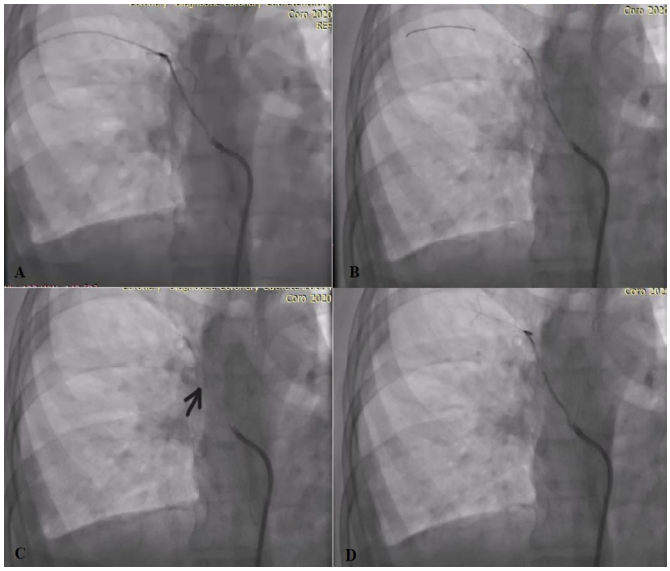

Figure 4. A. Bronchial artery was engaged with 7F amplatz left or amplatz right 2 catheters, **B.** The cut shaft of the balloon was pushed with its half, and the material to be left was stabilized by keeping the balloon shaft fixed to the proximal bronchial artery. Due to the unidirectional flow of the artery, the balloon was slightly expanded and placed in the location of the lesion, **C.** After the wire is retracted, the balloon is observed inside the artery (arrow), **D.** Control injection confirms that the vessel is occluded

RESULTS

The age range of the patients was between 26-79 years. 3 patients were female, 11 patients were male. 6 patients had lung cancer, 3 patients had tuberculosis, 1 patient had emphysema, 1 patient had hydatid cyst. The etiological characteristics of the patients are presented in the **Table**.

The objective of this study was to evaluate the immediate and prolonged outcomes of cases following selective bronchial system angiography and bronchial artery embolization. Significant observations related to hemoptysis on angiography include extravasation of contrast material, abnormal staining of lung tissue, tortuous course along the bronchial artery, an enlarged bronchial artery (more than 2 mm), and the existence of abnormal connections between bronchopulmonary arteries and veins. All patients exhibited a larger diameter of the bronchial artery. In all cases, with the exception of the increase in bronchial artery diameter, at least one other pathological sign was identified. The detected bleeding amounts, bleeding focus and embolized target vessel are presented in the **Table**.

Only one of 14 patients died 3 days after the intervention. A patient experienced severe bleeding as a result of the invasion of the left pulmonary artery. Consequently, the patient underwent surgery and underwent a left-sided pneumonectomy.

5 of our patients needed intensive care for 2-6 days (average 3.6 days).The number of hospitalization days, including the intensive care and service, of the patients, excluding the patient with Exitus, was between 2 and 10 days, and the patient was discharged with recovery in an average of 5.6 days. During the 6-month follow-up examination of the patients, there were no instances of complications or recurrence of bleeding.

DISCUSSION

Massive hemoptysis accounts for approximately 5% of all occurrences of hemoptysis and typically suggests the presence of a potentially serious respiratory or systemic illness. Mortality associated with major hemoptysis ranges from 6.5% to 38%.[8,9] The patient should be provided with advanced cardiac life support and stabilized as soon as possible. Medical treatment, bronchoscopic treatment, surgical treatments and angiographic embolization methods are the treatment options for patients. In our study, we demonstrated the effectiveness of an alternative pulmonary artery embolization method.

Table. Clinical information about patients who underwent intervention

Case	Age	Sex	Diagnosis	Hemoptysis (cc)	Focus of bleeding in bronchoscopy	Embolization location	Materiel (balloon)	Bronchial artery diameter (mm)	Duration of stay in the hospital
1	61	Male	Right middle lobe cavitary lesion	600	Right middle lobe	Right middle lobe feeding artery	3.0x12, 3.0x14	3	3 days intensive care, exitus
2	69	Male	Emphysema	450	Right upper lobe	Right main bronchial artery	3.0x24, 4.0x10	5	4 days service
3	64	Male	Right upper lobe squamous epithelium ca	200	Right upper lobe	Right middle lobe and upper lobe bronchial artery	2.5x15, 2.0x15	4	5 days service
4	57	Male	Left upper lobe	350	Left upper lobe	Left upper lobe bronchial artery	3.0x14	3	3 days service
5	52	Male	Right metastatic lung ca	550	Right upper lobe	Right main bronchial artery	4.0x10	4	10 days service
6	53	Male	Left hilar lung squamous epithelium ca	850	Left main bronchus	Left main bronchial artery	2.5x12, 2.75x15, 2.25x24	6	6 days intensive care, 4 days service
7	26	Female	Right middle lobe cavitary lesion	300	Right upper, middle and lower lobe	Right middle and lower lobe bronchial artery	2.5x24, 2.5x28	5	3 days intensive, 3 days service
8	65	Male	Left upper lobe squamous epithelium ca	400	Left upper lobe	Left main bronchial artery	3.0x18, 3.0x24	6	4 days intensive, 2 days service
9	64	Male	Left upper lobe squamous epithelium ca	350	Left main bronchus	Left main bronchial artery	3.0x24, 4.0x10	6.5	9 days service
10	60	Male	Bleeding from the left lower lobe	300	Left lower lobe	Left main bronchial artery	2.0x15, 2.0x10	4	3 days service
11	61	Male	Left upper lobe operated squamous epithelium ca	250	Left lower lobe	Left main bronchial artery	3.0x23, 3.0x14	6	2 days intensive care 2 days service
12	33	Male	Operated right upper lobe hydatid cyst	350	Right upper lobe	Right upper lobe bronchial artery	3.0x15, 4.0x10, 4.0x8	7	2 days service
13	79	Female	Previous tuberculosis, right destroyed lung, left emphysematous lung	300	Bilateral lung	Right and left main bronchial arteries	3.0x18, 3.0x18, 3.0x18	6.5	4 days service
14	73	Female	Right upper lobe	400	Right upper lobe	Right main bronchial artery	3.0x18	5	3 days service

Generally bronchoscopy is the preferred method in unstable patients. It can be applied at the bedside. When large blood clots cannot be removed effectively with bronchoscopy, it is highly effective to remove the frozen clot with a bronchoscope by embedding the cryoprobe into the clot. If there is no success in bronchoscopic and medical treatment, there are surgical and BAE treatment options. The chances of surgical treatment are low due to the low lung capacity of the patients and other accompanying health problems. Due to the low complication rate and high success rate in the treatment of BAE compared to surgical treatment, it has been a frequently used treatment method recently.[9] Hence, research on the BAE and alternative methodologies like ours hold significant worth.

The BAE indications include patients who are unable to undergo surgery, patients who refuse surgery but still require curative treatment, and patients who need temporary stabilization before surgical resection or medical treatment if other treatments have failed to control bleeding, thus enabling elective surgery. There are no absolute contraindications for bronchial artery embolization treatment, but coagulopathy, contrast allergy and renal failure are relative contraindications. We included in the study patients with massive bleeding findings and those who had failed other treatment options.

The pulmonary and bronchial arteries are the primary sources of blood supply to the lungs and their supporting structures.[10] The bronchial vessels typically arise from the aorta or intercostal arteries and enter the lung at the hilum. They then branch off at the mainstem bronchus to provide blood supply to the lower trachea, extrapulmonary airways, and supporting structures.[11] Angiographically, the bronchial arteries originate from the descending thoracic aorta between the upper T5 and lower T6 vertebral bodies in 70% of individuals.

In patients with hemoptysis, a little quantity of blood has the capacity to rapidly spill over into the respiratory system, so disrupting oxygenation and breathing, even if the bleeding is minimal. Therefore, there is no clear amount of bleeding in life-threatening massive hemoptysis.[12] However, associated mortality is rather high and has been shown to be mainly related to the rate of bleeding.[13] We observed that there was a relatively large amount of bleeding in the exitus case (600cc).

When compared to the mortality rates revealed by other studies in the literature, the BAE technique with the parachute method appears to be effective. In-hospital mortality occurred in only one patient. In addition, recurrent and persistent hemoptysis may occur after embolization and can be seen within 6-12 months in 10-20% of cases.[14] No recurrent bleeding occurred in BAE patients with the parachute method during their 6-month follow-up. This method is effective and safe in the short and long term. However, studies with higher case numbers and longer follow-up periods are needed on this subject.

The common embolizing agent utilized was polyvinyl alcohol, with a growing trend towards the adoption of glue in recent years.[15] We identified the site of bleeding by diagnostic techniques and thereafter carried out focused embolization. This led to an improvement in processing efficiency and a reduction in processing time.

Five of the patients required intensive care after the procedure. 8 patients whose hemodynamic stability was achieved were followed in the inpatient ward. Procedure times were not documented in the study data, but it was observed that it was partially effective in a shorter time than other treatment options. Therefore, long intensive care needs were not observed in patients who received effective intervention in a short time.

A potential complication of the parachute approach is the migration of the free balloon from the vascular region. However, migration is unlikely due to unidirectional blood flow in the distal vascular bed. We did not observe any such complications in our cases. An additional potential hazard could be the occurrence of an infection. Prophylactic antibiotics may be administered to minimize the likelihood of infection.

These cases were considered as an invasive solution when the supply chain was broken during the COVID-19 period and the coil material was not available. The difference of our balloon embolization is that by dividing the balloon into two, placing the open side of the balloon opposite to the flow, the balloon expands with the effect of the current and obtaining a larger embolized area with a amaller material.

Limitations

The lack of a control interval in our study is one of the limitations of the study, but the results obtained have shown that the technique is useful.

CONLUSION

In our study, we presented 14 patients who underwent BAE using a new method called the parachute technique. The bronchial artery was embolized successfully in all patients. Our technique did not involve the use of embolization material. Instead, arterial embolization was carried out using the parachute technique, which involved the placement of handmade modified balloons in the direction of blood flow. There were less complications because no embolization material was utilized. Also, the cost has been very cheap. In summary, balloon embolization with the parachute technique may be an effective and safe treatment option in patients with massive hemoptysis. And in this regard, it may pave the way for new treatment modalities and the creation of novel devices in the future.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was conducted with the permission of Fırat University Non-interventional Researches Ethics Committee (Date: 31.12.2020, Descision No: 2020/17-36).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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