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ORIGINAL ARTICLE

THORACIC

A retrospective review comparing the treatment outcomes of emergency lung resection for massive haemoptysis with and without preoperative bronchial artery embolization

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Abstract

OBJECTIVES: The objective of this review was to determine the feasibility of emergency lung resection for massive haemoptysis without preoperative bronchial artery embolization (BAE). The potential for fatal recurrent haemoptysis following BAE may be avoided if surgery is undertaken instead. Furthermore, if the outcomes for emergency lung resection with and without BAE are equivalent, it may be advisable to bypass BAE and proceed directly to resection.

METHODS: A retrospective review of case records from January 2005 to October 2007 of patients admitted to the Department of Cardiothoracic Surgery with massive haemoptysis deemed suitable for emergency lung resection was undertaken. Following urgent clinical evaluation, emergency lung resection with or without preoperative BAE was undertaken. If BAE was selected, the timing of lung resection was dependent upon the presence of recurrent haemoptysis.

RESULTS: Sixty-one patients with massive haemoptysis were deemed suitable for emergency lung resection. Forty-one patients had lung resection without BAE. One patient (2%) had recurrent minor haemoptysis after surgery. Other complications included 2 deaths, 1 post-resection empyema thoracis and 1 deep thoracotomy wound infection. Twenty patients underwent surgery following BAE. Fifteen (75%) patients had recurrent haemoptysis after BAE. None developed recurrent haemoptysis after surgery. Other complications included 1 death and 2 post-resection empyema thoraces.

CONCLUSIONS: This retrospective study suggests that emergency lung resection is feasible in appropriately selected patients presenting with radiologically localized disease and massive haemoptysis. These data also suggest that BAE is probably best utilized as a temporizing measure in patients unsuitable for emergency lung resection.

Keywords: Airway • Bleeding • Bronchial arteries • Lobectomy • Lung pathology

INTRODUCTION

Current consensus advocates bronchial artery embolization (BAE) as the initial form of therapy for massive haemoptysis with radiologically localized disease even if emergency lung resection is deemed suitable [1–4].

Massive haemoptysis has been associated with an extremely high mortality. Death is usually due to asphyxiation rather than exsanguination.

Conservative management of massive haemoptysis has a mortality of 50–100% [2, 5]. Knott-Craig *et al*. [2] showed that 36% of patients treated medically for massive haemoptysis had a recurrent bleed within 6 months. Of these, 45% were fatal. No patients who underwent lung resection for massive haemoptysis had recurrent haemoptysis after 6 months.

Mortality rates for surgery for massive haemoptysis vary between 7 and 18% [2, 3]. This increases up to 40% when emergency surgery is undertaken in the presence of active haemoptysis [2–4, 6]. Mortality is not affected by the aetiology, tuberculosis (TB) activity, lack of therapy, age or sex of the patient [6]. The most significant factor influencing outcomes is soiling or aspiration involving the contralateral normal lung [2, 6].

BAE may be used either as a temporizing measure or definitive therapy. When used as a temporizing measure, it is thought to allow sufficient time for adequate resuscitation of the patient and clearing of blood from the bronchial tree prior to lung resection. This was thought to improve patient outcomes [1–4]. However, up to 20–45% of patients have recurrent haemoptysis within the first month following BAE [1, 3, 7].

Other treatment modalities for massive haemoptysis include ice-cold saline lavage of the airways with rigid bronchoscopy, instillation of vasoconstrictors into the bronchial tree, cellulose tamponade of the bronchi, cavernostomy, radiotherapy in cases of massive haemoptysis from irresectable bronchial carcinoma and instillation of intravenous antifungal agents into mycetoma-containing cavities of the lung [3, 4, 8–10]. These studies involved

small cohorts and appear insignificant to warrant routine use. Instead, these treatment options should be considered as salvage procedures if lung resection is contraindicated.

AIM

To compare the composite outcomes of mortality, recurrent haemoptysis and procedural morbidity between lung resection alone vs BAE prior to lung resection in patients presenting with massive haemoptysis.

MATERIALS AND METHODS

Case records from January 2005 to October 2007 of patients admitted with massive haemoptysis to the Department of Cardiothoracic Surgery, Inkosi Albert Luthuli Central Hospital, were reviewed. Due to the unavailability of an interventional radiologist, BAE was not offered as emergency intervention after October 2007.

Inclusion criteria

(i) Arterial blood gas PaO_2 >60 mmHg and $PaCO_2$<45 mmHg were the lower limits for lung resection.
(ii) Full blood count haemoglobin >10 g/dl. Blood transfusions were undertaken either preoperatively or intraoperatively if necessary.
(iii) Liver function and renal function tests Albumin > 30 g/dl.
(iv) Normal or negligible renal dysfunction such that BAE and lung resection were permissible.
(v) Human immunodeficiency virus (HIV) status cluster of differentiation 4 (CD4) count >200 or an undetectable viral load if patients were on antiretroviral therapy. These parameters were only considered for non-emergent lung resection.
(vi) Radiology routine chest radiograph.

A high-resolution CT scan of the chest was almost always undertaken in haemodynamically stable patients.

Localized lung disease was considered to be lobar disease less than or equivalent to one lung while extensive bilateral lung disease was greater than this.

Exclusion criteria

(i) Haemorrhage of extrapulmonary aetiology.
(ii) Extensive soiling of the pulmonary tree necessitating BAE.

Massive haemoptysis was defined as a single bout of 250 ml or more of blood or 600 ml of blood in 24 h.

Following admission to a high-dependency unit, a detailed history and examination was performed as a preliminary method of assessing the feasibility of lung resection. Feasibility for surgery refers to lung resection with acceptable surgical outcomes once an objective assessment using the preoperative inclusion criteria was carried out.

Depending on the possible aetiology of the underlying lung disease, anti-TB therapy and broad spectrum intravenous antibiotics were usually commenced.

Thereafter, either emergency lung resection without BAE or BAE as a temporizing measure prior to lung resection was undertaken. Following successful BAE, lung resection was undertaken within 72 h or undertaken as emergency surgery in the event of recurrent haemoptysis. The decision regarding temporizing surgical patients with BAE was at the discretion of the Consultant Cardiothoracic Surgeon on duty.

A comparison of the outcomes (recurrent haemoptysis, morbidity and mortality) of each modality of therapy were analysed. All patients were followed up for a minimum period of 12 months.

Univariate analysis of all categorical data using descriptive statistics and either Fisher's exact test or Pearson's χ^2 test where appropriate was undertaken. All continuous data were analysed using descriptive statistics and compared using independent samples *t*-test or Mann–Whitney *U*-test where appropriate. A *P*-value of <0.05 was considered significant for all comparisons. A multivariate logistic regression was not conducted as the sample included <10 outcome events per variable.

RESULTS

An analysis comparing the occurrence of (i) recurrent haemoptysis following treatment; (ii) morbidity and mortality and (iii) composite outcomes (this includes both recurrent haemoptysis and morbidity and mortality) between those patients temporized with BAE prior to surgery and those treated with surgery alone using Fisher's exact test showed the following association between the two groups (Table 2).

Table 1: Demographics of patients admitted

	Surgery alone (*n* = 41)	BAE and surgery (*n* = 20)
Age		
Median	38	33
Range	51 (10–61)	44 (14–58)
Male	28	11
Black	35	19
Active TB	19	6
Aspergilloma	7	6
Bronchiectasis	15	8
Previous TB	21	12
HIV	14 (*n* = 34)	11 (*n* = 19)
CD4 < 200	4 (*n* = 11)	3 (*n* = 10)

TB: tuberculosis; HIV: human immunodeficiency virus; CD4: cluster of differentiation 4.

Table 2: Comparison of outcomes between surgery alone vs BAE and surgery

	Surgery alone (*n* = 41)	BAE and surgery (*n* = 20)	*P*-value
Recurrent haemoptysis	1	15	<0.00001
Protocol morbidity	2	2	0.59
Mortality	2	1	1.00
Composite outcomes	5	18	<0.00001

Recurrent haemoptysis

Fifteen of 20 (75%) patients temporized with BAE had recurrent haemoptysis. One of the 41 patients (2%) who underwent lung resection without BAE developed recurrent haemoptysis (P-value < 0.0001).

Morbidity and mortality

Complications following BAE and lung resection included 1 death and 2 post-resection empyema thoraces (5% mortality; 10% morbidity). Complications following lung resection alone included 2 deaths, 1 post-resection empyema thoracis and 1 deep thoracotomy wound infection (5% mortality; 5% morbidity). This was not statistically significant.

Composite outcomes

Complications were noted in 18 patients (90%) in the BAE and surgery group compared with 5 patients (12%) who complicated in the surgery without the BAE group (P-value < 0.0001).

MORTALITY

With preoperative BAE

The single death was due to fulminant septicaemia from multidrug-resistant Gram-negative Acinetobacter. This patient with acquired immune deficiency syndrome (AIDS) (CD4 count: 126) required an emergency left pneumonectomy and massive blood transfusion and postoperative ventilation as a consequence of spill was necessary. Death occurred 10 days after surgery.

Without preoperative BAE

The first death was due to septic shock resulting in multiple organ failure. Nine days after surgery, the patient developed a bronchopleural fistula (BPF), which was treated with closed tube drainage. Despite mechanical ventilation and broad spectrum antibiotics, the patient demised 3 weeks later.

The second death occurred suddenly on Day 2 following surgery. Prior to and during emergency lung resection, there was active haemoptysis. This patient had AIDS (CD4 count: 127), was not on highly active antiretroviral therapy (HAART), required a short period of postoperative mechanical ventilation and demised on Day 2 while awaiting transfer to the general ward. The aetiology of death was probably aspiration due to a BPF.

MORBIDITY

With preoperative BAE

The first patient with a post-resection empyema thoracis was HIV positive and underwent an emergency lung resection for recurrent massive haemoptysis 2 days after successful BAE. Intraoperatively, no mycetoma-containing cavity was breached and histology of the lung showed bronchiectasis. The patient was treated with open drainage.

The second patient with a post-resection empyema thoracis requiring open drainage was HIV positive on HAART with an unknown viral load. Elective lung resection was undertaken after successful BAE.

Without preoperative BAE

The patient who developed a post-lobectomy empyema thoracis treated with open drainage had ongoing massive haemoptysis. This patient had AIDS (CD4 count: 157), was not on HAART and required a massive blood transfusion perioperatively. Intraoperatively, the aspergilloma-containing cavity was breached. Mechanical ventilation due to hypothermia and acidosis resulting from prolonged surgery was required overnight.

Deep thoracotomy wound infection developed in a patient who underwent an emergency left pneumonectomy. This patient was HIV positive (CD4 count: 209), with a haemoglobin of 8.6 g/dl and an albumin of 28 g/dl. The patient had been diagnosed with active TB and treated accordingly for 4 weeks preoperatively. Intraoperatively, the patient had a hypoxic arrest necessitating a short period of cardiopulmonary resuscitation and postoperatively required 12 h of mechanical ventilation. Definitive treatment involved wound debridement and secondary closure.

DISCUSSION

It is incontestable that in patients presenting with massive haemoptysis, lung resection is usually curative and BAE temporizing. Despite this, BAE has been advocated prior to surgery in all patients with massive haemoptysis including those with active haemoptysis requiring little or no preoperative preparation. This treatment strategy was borne from the high morbidity and mortality previously associated with undertaking emergency lung resection in these patients. However, these results may have been a consequence of poor surgical selection. With appropriate preoperative evaluation, this review has shown similar outcomes for both emergency and elective lung resection for massive haemoptysis without preoperative BAE compared with BAE prior to lung resection.

Recurrent haemoptysis following BAE occurs in up to 20–45% of patients at 1 month [1, 3, 7]. This may be due to incomplete occlusion of the feeding vessels, recanalization of previously embolized vessels or the development of new collaterals or inadequate treatment of the underlying disease [1, 7, 9]. The high early failure rate of BAE makes emergency lung resection extremely hazardous, since these patients actively bleed at the time of surgery. This leads to an increased risk of soiling of the normal lung resulting in a higher complication rate. Furthermore, curative lung resection may not be feasible thereafter.

In this review, 15 patients (75%) temporized with BAE prior to lung resection had recurrent haemoptysis following BAE. Of these, 7 (47%) had recurrent bouts of massive haemoptysis necessitating emergency surgery.

BAE was undertaken emergently by the on-call radiologist using primarily polyvinyl alcohol sponges for embolotherapy for both bronchial and non-bronchial sources of haemoptysis. Unless suspected, no attempt was routinely made to assess for a possible pulmonary artery source of the haemorrhage.

Recurrent haemoptysis following surgery for massive haemoptysis may occur in up to 5% [3]. This may be due to incomplete excision of the underlying diseased lung, progression or reactivation of disease or development of new lung pathology.

Table 3: Lung resections undertaken for massive haemoptysis

	Surgery alone	BAE and surgery
Right pneumonectomy	2	3
Left pneumonectomy	10	3
Right upper lobectomy	8	4
Left upper lobectomy	14	6
Right lower lobectomy	3	1
Left lower lobectomy	2	
Right upper and middle lobectomy	1	1
Middle lobectomy		1
Middle and right lower lobectomy	1	1

This review showed that 1 of 41 (2%) patients had recurrent haemoptysis following emergency surgery for massive haemoptysis. This was attributed to recurrent primary pulmonary TB which was successfully treated with anti-TB therapy.

Furthermore, complications of lung resection for massive haemoptysis following BAE included: 1 death (1/20; 5%), as a consequence of respiratory failure due to a post-lung resection bronchopneumonia and 2 patients (2/20; 10%) who developed a post-resection empyema thoracis.

Surgery for massive haemoptysis without BAE resulted in the following complications: 2 deaths (2/41; 5%) both as a consequence of respiratory failure exacerbated by post-resectional BPF and 1 patient (1/41; 2%) who developed a post-resectional empyema thoracis.

In this series, all-cause mortality was assessed. The difference in mortality as well as morbidity between these two groups was not significant. This questions the previously held belief that BAE undertaken prior to lung resection improves outcomes especially in those patients presenting with active massive haemoptysis.

These figures compare favourably with the current complication rates worldwide, which show an 18–30% occurrence of post-operative BPF and post-resectional empyema thoraces in patients undergoing surgery for massive haemoptysis following BAE [4]. Andrejak *et al*. showed a 5–11% occurrence of post-resection BPF following emergency lung resection with active haemoptysis. This figure increased to 20% for elective lung resections after preoperative BAE. Though not mentioned, this may be due to emergency lung resection undertaken in patients with a soiled bronchial tree following recurrent massive haemoptysis after 'successful' BAE.

HIV and cardiothoracic surgery has not been extensively reviewed. Our unit experience has allowed us to formulate criteria: CD4 count >200 or an undetectable viral load in patients on antiretroviral therapy for undertaking elective cardiothoracic surgery in the HIV patient. If life-saving emergency lung resection for massive haemoptysis was undertaken, inclusion criteria other than the HIV status were assessed to determine the feasibility of surgery.

A large proportion of patients who underwent surgery were HIV positive and had active TB (Table 2). It is possible that HIV infection may affect recurrent haemoptysis following both BAE and surgical intervention. In a *post hoc* analysis, the influence of HIV on the treatment outcomes of (i) the surgery-alone group and the (ii) surgery with the BAE group was analysed. HIV infection was not found to be significantly associated with recurrent haemoptysis in both groups.

In this study, active TB was not a statistically significant risk factor for complications following lung resection for patients presenting with active massive haemoptysis.

In addition, this review did not show a significant association between a right pneumonectomy and post-resection empyema thoraces or a BPF. As expected, left sided lung resection was the most common operation undertaken (Table 3).

All bronchial stumps were closed with interrupted Vicryl® (Johnson and Johnson) absorbable sutures. Reinforcement of the bronchial stump with a muscle flap was rarely carried out.

STUDY LIMITATIONS

Eight thoracic surgeons were practising in our unit at this time. Our unit was of the opinion that the literature regarding timing of surgery and the benefits of BAE as temporizing therapy was unconvincing. Some surgeons prescribed the 'cooling off' period using BAE and others felt this unnecessary especially if surgery was undertaken during daylight hours. This could possibly have resulted in bias. Nevertheless, it is important to remember that upon admission all patients in this cohort met the inclusion criteria for emergency lung resection without BAE and following this retrospective review our unit policy has changed accordingly.

In addition, this is a single-centre observational study that needs to be tested prospectively.

CONCLUSION

This retrospective review suggests that if feasible, all patients with massive haemoptysis and localized pulmonary disease should undergo emergency lung resection without undertaking BAE as a temporizing measure. The preliminary data in this study show a significant difference in recurrent haemoptysis if surgery is undertaken without BAE as a temporizing measure. The previous belief of not undertaking emergency lung resection in patients with active massive haemoptysis because of the associated prohibitively high morbidity and mortality was not evident in this series.

Therefore, BAE as a temporizing measure should probably not be undertaken in patients who are suitable for surgery, since delayed lung resection places these patients at an unnecessary risk of possible fatal recurrent massive haemoptysis.

Though prospective studies are required, it is suggested that BAE be reserved for patients who refuse or are deemed unsuitable for surgery [11, 12].

Conflict of interest: none declared.

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