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Simultaneous cardiac surgery with pulmonary resection: presentation of series and review of literature¹

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Abstract

Background: The issue of performing simultaneous pulmonary resection and cardiac surgery in patients with coexisting lung carcinoma and ischaemic heart disease remains controversial. We report our experience and review the literature. **Methods:** Thirteen patients (male ten, female three; mean age 65 years) underwent simultaneous cardiac surgery and pulmonary resection. Lung pathology consisted of primary lung carcinoma ($n = 10$), benign disease ($n = 2$) and carcinoid ($n = 1$). Lung resections included pneumonectomy ($n = 3$), lobectomy ($n = 4$), segmentectomy ($n = 1$) and local excision ($n = 5$). Cardiac procedures consisted of coronary artery bypass grafting (CABG) in 11, aortic valve replacement in one and mitral valve repair with CABG in one patient. In all but one case the lung resection was performed prior to heparinization and cardiopulmonary bypass (CPB). In two patients, with suitable coronary anatomy, myocardial revascularization without CPB was performed to reduce morbidity. **Results:** There was no hospital mortality. Postoperative blood loss and ventilation requirements were reduced in the patients who were operated on without CPB. Prolonged ventilatory support was required in two cases. All patients with benign pathology are alive. In the lung cancer group there have been five late deaths: disseminated metastatic disease ($n = 3$), anticoagulant related haemorrhage ($n = 1$) and broncho-pleural fistula ($n = 1$). Of the remaining five patients four are alive and disease free 7–23 months post-operatively; one patient has recurrent disease 40 months post-operatively. **Conclusions:** Simultaneous pulmonary resection and cardiac surgery is associated with acceptable operative morbidity and mortality. In patients with lung carcinoma long-term survival was determined by tumour stage. The avoidance of CPB may be advantageous by decreasing blood loss and ventilation requirements. © 1998 Elsevier Science B.V. All rights reserved

Keywords: Lung cancer; Cardiac surgery

1. Introduction

The management of patients with resectable lung tumours and coexisting cardiac disease is subject to debate as the operative mortality for lung resection in such patients is increased [1]. Traditionally the surgical procedures have been staged, with the cardiac surgery performed first followed by the pulmonary resection at a later date. With this approach the tumour resection is delayed and there is the

morbidity and additional cost of two operations. Furthermore, exposure to the immunosuppressive effects of cardiopulmonary bypass (CPB) may have a deleterious effect on tumour growth and dissemination. Alternatively, the cardiac surgery and the pulmonary resection can be performed simultaneously and thus avoid a second procedure. However, concern exists regarding the adverse effects of systemic heparinization and CPB in patients undergoing lung resection and the adequacy of exposure through a median sternotomy.

We present a series of 13 patients who underwent simultaneous pulmonary resection and cardiac surgery. In patients with suitable coronary anatomy myocardial revascularization was performed without CPB to avoid the

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detrimental effects associated with heparinization and extra-corporeal circulation.

2. Patients and methods

The clinical records of all patients who underwent simultaneous cardiac surgery and pulmonary resection from April 1990 to March 1997 were reviewed (Table 1). In total there were 13 patients (ten male, three female) with mean age 65 years (range 59–75). The majority (nine patients; 69%) presented with cardiac symptoms, myocardial ischaemia or valvular heart disease, the pulmonary lesion being identified during the preoperative assessment (seven patients) or as an incidental finding at cardiac surgery (two patients). Haemoptysis was the primary presentation in four patients with lung carcinoma and ischaemic heart disease was discovered during their assessment.

2.1. Cardiac pathology

Eleven patients had coronary artery disease (single vessel disease in one, two-vessel disease in one and triple-vessel disease in nine patients). One patient had bicuspid aortic valve stenosis with a peak gradient of 90 mmHg. One patient had rheumatic mitral valve stenosis with a valve area of 1 cm² with three-vessel coronary artery disease. Left ventricular function determined by ventriculography or echocardiography was assessed as normal in 7 (58%) and moderately impaired in 6 (42%) patients.

2.2. Pulmonary pathology

Pathology consisted of primary lung carcinoma in ten patients (squamous cell carcinoma in four, adenocarcinoma in five and large cell carcinoma in one) carcinoid in one and benign disease in two patients (hamartoma and rheumatic nodule). Standard preoperative investigations consisted of chest X-ray, computerised axial tomography (CT), bronchoscopy and pulmonary function testing. It was possible to establish a preoperative tissue diagnosis in seven patients using bronchoscopy in three or CT guided fine needle aspiration biopsy in four patients. An intraoperative frozen section analysis was performed in two cases identifying squamous cell carcinoma and rheumatoid nodule. Additional investigations were performed only with a specific clinical indication and included CT brain scan ($n = 1$), cytology of pleural fluid ($n = 1$), radioisotope bone ($n = 2$) and ventilation/perfusion lung scans ($n = 2$).

2.3. Operative details

Following induction of anaesthesia all patients with preoperatively established lung pathology had a double lumen endotracheal tube positioned to allow single lung ventilation.

Eleven patients were operated via a standard median sternotomy for the cardiac and lung procedures. A median sternotomy extended into the left fourth intercostal space was necessary in one patient for a left lower lobectomy. A separate right posterolateral thoracotomy was used to perform a right upper lobectomy in one patient in whom the CT scan suggested the possibility of chest wall invasion.

Table 1

Patient clinical and pathological characteristics

No	Sex	Age	Lung pathology	Lung resection	TMN	Cardiac procedure	Survival
1	F	63	Adenocarcinoma	Right apical segmentectomy	T1 N0 M0	Aortic valve replacement	Died CVA 36 months
2	M	61	Adenocarcinoma	Right upper lobectomy	T3 N0 M0	CABG X3	Died brain metastases 8 months
3	M	64	Large cell carcinoma	Left upper lobectomy	T3 N0 M0	CABG X3	Died malignancy 18 months
4	M	68	Squamous cell carcinoma	Right upper lobectomy	T2 N0 M0	CABG X3	Local recurrence 40 months
5	M	63	Adenocarcinoma	Left lower lobectomy	T2 N0 M0	CABG X3	Well 30 months
6	M	69	Squamous cell carcinoma	Right pneumonectomy	T3 N0 M0	CABG X3	Died BP fistula 3 months
7	M	67	Adenocarcinoma	Left upper lobe wedge excision	T1 N0 M0	CABG X4	Well 39 months
8	F	62	Adenocarcinoma	Left upper lobe wedge excision	T1 N0 M0	CABG X4	Well 12 months
9	M	68	Squamous cell carcinoma	Right pneumonectomy	T2 N0 M0	CABG X3 ^a	Well 14 months
10	M	64	Adenocarcinoma	Left pneumonectomy	T3 N1 M0	CABG X1 ^a	Died malignancy 6 months
11	F	63	Carcinoid	Right middle lobe wedge excision	–	CABG X3 mitral valvotomy	Well 48 months
12	M	59	Rheumatoid nodule	Left upper lobe wedge excision	–	CABG X2	Well 32 months
13	M	75	Hamartoma	Right upper lobe enucleation	–	CABG X5	Well 24 months

^aWithout cardiopulmonary bypass.

Following access to the chest cavity the lung resection was performed prior to heparinization and CPB in 12 patients (92%). One patient (No. 9), while dissecting the pulmonary lesion, became hypotensive and developed ventricular fibrillation; when emergency CPB had been safely established the pulmonary resection was then completed.

All patients who had a pre-operative diagnosis of malignancy underwent formal anatomical resection. Apical segmentectomy of right upper lobe was performed in one, lobectomy in four and pneumonectomy in three patients. Wedge resection was performed in two patients each with a small peripheral carcinoma discovered as an incidental finding during cardiac surgery. Wedge resections were also performed for the carcinoid and rheumatoid nodule; the hamartoma was enucleated. Mediastinal and hilar lymph node excision was performed in seven patients with lung carcinoma. Nodal excision was not performed in three patients each with T1 peripheral tumours and without evidence of nodal enlargement on the CT scan. In patients requiring pneumonectomy the pericardium and the pleural layers were approximated to separate the pleural and pericardial cavities preventing cardiac dislocation. When the pulmonary resection and lymph node dissection had been completed haemostasis was secured prior to heparinization.

Institution of CPB with systemic heparinization was used in 11 patients with standard techniques of myocardial protection employed: intermittent cross-clamping was used in two and antegrade cardioplegia in nine (blood in one, crystalloid in eight) patients. The bypass time ranged from 72 to

144 min (mean 92) and the cross-clamp time ranged from 19 to 67 min (mean 49).

Two patients, following pneumonectomy, underwent CABG on the beating heart without CPB. Heparin was administered in a dosage 100 U/kg (1/3 dose for CPB). Intermittent small doses of a short acting beta-blocker (Esmolol) was administered to decrease the heart rate and blood pressure. In order to construct accurate distal anastomoses stay sutures (3 0 Prolene with Teflon plegets) were placed proximal and distal to the coronary arterotomy to provide a stable bloodless field. In total 11 patients underwent CABG, (range 1–5 grafts, mean three grafts/patient). The internal mammary artery was used in three patients only. One patient underwent triple CABG and open mitral valvotomy and one patient underwent aortic valve replacement with a bileaflet mechanical prosthesis.

Prior to closure chest drains were placed: two in the mediastinum (one anterior, one basal) and two in the pleural cavity (one apical, one basal); following pneumonectomy the pleural cavity was not drained.

3. Results

3.1. Hospital morbidity and mortality

There was no operative mortality. Patients were electively ventilated overnight except for the two patients in which CPB was not employed, who were extubated within 3 h of surgery. Prolonged ventilatory support was necessary

Table 2

Simultaneous pulmonary resection and cardiac surgery: review of literature

Author year	Study dates	Total patients	Lung cancer	Post-op. mortality	Cause of mortality	Lung cancer survival
Dalton, 1978 [7]	1971–78	3	3	0	–	Not quoted
Bricker, 1980 [8]	1980	3	2	0	–	2 CD 35–42 months
Girardet, 1981 [9]	1965–83	3	1	0	–	1 alive 11 months
Piehler, 1985 [10]	1965–83	43	10	2 (4.6%)	Myocardial infarction. Pulmonary haemorrhage	6 alive 3–69 months; 3 CD 10–30 months
Hura, 1987 [11]	1979–85	6	6	0	–	3 alive 6–23 months; 3 CD 5–36 months
Canver, 1990 [12]	1982–88	21	8	1 (4.8%)	Sternal dehiscence /sepsis	6 alive 13–84 months; 1 CD 77 months
Ulincy, 1992 [13]	1980–90	19	5	1 (5.3%)	ARDS	2 alive 24–94 months; 3 CD 3.5–21 months
Yokoyama, 1993 [14]	1988–92	11	11	0	–	5 alive 1–19 months; 4 CD 5–22 months
Rosalion, 1993 [15]	1982–92	10	10	0	–	7 alive 12–38 months; 3 CD 3–13 months
Miller, 1994 [16]	1965–92	30	30	2 (6.7%)	–	5YS 34.9%
La Francesca, 1995 [17]	1973–90	21	21	–	–	5YS 52%
Brutel Riviere, 1995 [18]	1979–93	79	79	5 (6.3%)	Sepsis, CVA, sudden iatrogenic	5YS 42%
Rao, 1996 [19]	1982–95	30	17	2(6.5%)	Aspiration CVA	5YS 80%
Danton, 1997	1990–97	13	10	0	–	6 alive 1–24 months; 2 CD 6–14 months

CD, cancer related death; 5YS, 5-year survival; MI, myocardial infarction; ARDS, adult respiratory distress syndrome.

in two patients (38 and 48 h) one of whom developed a left lower lobe collapse with retained secretions and required bronchoscopy. The other became confused post-operatively and reintubation was required to maintain an airway and to clear chest secretions. The postoperative blood loss tended to be less in patients who avoided CPB and systemic heparinization (mean = 300 ml; range 40–560 ml) compared with the bypass group (mean = 926 ml; range 400–2080 ml). No patient required re-exploration for excessive bleeding. One patient sustained an enzyme proven myocardial infarction which was not haemodynamically significant. Four patients developed supraventricular dysrhythmia and were managed with digoxin. We avoided the use of Amiodarone because of its possible association with the development of adult respiratory distress syndrome (ARDS) following lung resection [2]. There were no episodes of wound or chest space infection.

3.2. Follow-up

Follow up data was available on all patients ranging from 1 to 48 months (mean = 23.8). Of the ten patients with bronchogenic carcinoma, five are currently alive: four patients have no evidence of disease at postoperative intervals ranging from 12 to 39 months (mean = 23.7), one patient (No. 4) is presently undergoing radiotherapy for local recurrence 40 months postoperatively. Three patients have died from metastatic carcinoma 6, 8 and 18 months postoperatively; each had Stage 111A tumours. There have been, in addition, two non-cancer related deaths. One patient (No. 6) was readmitted 3 months following uncomplicated right pneumonectomy with a broncho-pleural fistula and pleural space infection. The pleural cavity was drained for symptom control but because of his generalised debility repeat thoracotomy and surgical closure was not performed. He succumbed to systemic sepsis. Another patient (No 1) on long-term anticoagulant treatment following the mechanical aortic valve replacement, had a fatal subdural haemorrhage. The three patients with either benign disease or carcinoid are alive and symptom free 24–48 months post operatively.

4. Discussion

In patients with lung carcinoma amenable to surgery, resection offers the best hope for cure. Following resection of stage I non-small cell lung cancer 5-year survival rates of 65–92% have been achieved [3]. If however, such a patient has in addition coexisting cardiac disease the operative mortality following lung resection is significantly increased [1]. Performing the myocardial revascularization prior to the pulmonary resection, as in a staged procedure, reduces the postoperative morbidity and mortality [4,5].

The staged procedure has, however, several disadvantages. It involves the cost and morbidity of two separate

operations. The operative mortality in patients with coexisting lung disease undergoing CABG is significantly increased [6]. Delaying the lung resection will allow time for tumour growth and dissemination; which may be enhanced by the altered immune response sustained during CPB at the time of the cardiac surgery.

A logical solution is to perform the pulmonary resection with the cardiac procedure simultaneously [7–19](Table 2) although some surgeons have expressed a reluctance to such an approach [13,16]. The principle concerns are of inadequate exposure for lung resection through a median sternotomy and the adverse effects of CPB, particularly perioperative coagulopathy and immunosuppression. In patients undergoing myocardial revascularization with suitable coronary anatomy the avoidance of CPB may be beneficial by reducing the associated morbidity. Simultaneous pulmonary resection and myocardial revascularization without CPB has been described for lobectomy.[20]. To our knowledge simultaneous pneumonectomy and CABG without CPB, as performed in the present series, has not been previously reported.

Median sternotomy was employed in the majority of patients in the present series as it allowed the cardiac and pulmonary surgery to be performed through a single incision. It offers good exposure to both lung hila and has been employed by some authors as their standard approach for routine pulmonary resection [21]. Compared with posterolateral thoracotomy, median sternotomy has been associated with a reduction in postoperative pain and analgesic requirements and a quicker recovery of pulmonary function [22]. Left lower lobectomy is technically the most difficult pulmonary resection through a median sternotomy as the dissection tends to be obscured by the heart and retraction may induce dysrhythmias and haemodynamic instability. This resection can be facilitated by extending the incision laterally into the intercostal space [22] as performed in one patient in the present series.

Access to the posterior mediastinum for lymph node sampling is possible although more difficult compared with that of thoracotomy [13,14]. A separate postolateral thoracotomy may still be necessary for certain tumours invading the chest wall. However, when two incisions have been employed post-operative pain and mortality increases [18] and if possible this is best avoided. Sternal infection and dehiscence is a potential complication [12,13] but was not realised in the present series.

Patients who undergo heart surgery with CPB are at substantial risk of postoperative bleeding [23]. Bleeding can result from excessive heparinization, inadequate heparin neutralisation or protamine excess. More commonly it is the result of a transient impairment of platelet function mediated by platelet activation during passage through the extra-corporeal circuit [24]. In patients undergoing a concomitant procedure, bleeding may arise both from the area of the lung resection and mediastinal node dissection and accounts for a significant cause of postoperative morbidity

[13,14]. Piehler et al. described one fatality resulting from intrapulmonary haemorrhage following multiple pulmonary wedge excisions for metastatic carcinoma [10]. CABG without CPB significantly reduces post operative bleeding and transfusion requirements [25]. To reduce the risk of bleeding in the present series, patients with suitable coronary anatomy underwent CABG, without CPB. Alternatively, when CPB was necessary the lung resection was performed prior to heparinization and its institution. Furthermore anatomical resections of the lung were preferred to wedge excisions in order to reduce the risk of intraparenchymal haemorrhage.

Pulmonary dysfunction sustained during CPB may adversely affect the outcome in patients undergoing simultaneous lung resection and cardiac surgery. Mechanisms of lung injury include fluid overload, activation of the inflammatory response and endothelial cell injury [26]. These effects become increasingly important in patients with established lung disease [27] which may often coexist in patients with pulmonary neoplasm. By avoiding CPB for CABG the lung injury is ameliorated and early extubation is possible [28]. Both patients in the present series who avoided CPB underwent pneumonectomy and early extubation was performed without adverse respiratory sequelae. Alternatively in patients requiring CPB for cardiac surgery potential therapeutic options to attenuate lung injury include reducing fluid retention by haemoconcentration [29] and leukocyte filtration [30]. We avoided intravenous Amiodarone in the management of postoperative arrhythmias because of the associated risk of ARDS following lung resection [2].

There has been concern expressed regarding that alterations in the immune system following cardiopulmonary bypass which may enhance malignant growth and decrease long term survival in patients with coexisting cancer. Several authors demonstrated that in patients undergoing combined surgery long-term survival is improved if the lung cancer is resected prior to CPB compared with during CPB [18,19]. However, there does not appear to be an increase in cancer recurrence in patients with previously treated malignant conditions who subsequently undergo cardiac surgery [31]. Immunological alterations following CPB include depression of cell mediated immunity with decreased T-cell subsets [32], reduction in natural killer (NK) cell activity [33], and depressed granulocyte chemotaxis [34]. These deleterious effects on the host defence may explain the high incidence of opportunistic microorganisms in nosocomial infections among patients undergoing cardiac surgery [35]. However, the specific effects of CPB on tumour growth and dissemination in patients with coexisting malignant disease remain largely unknown. A transient perioperative depression of immune function may provide a window for malignant growth and dissemination in patients with coexisting disease. By performing simultaneous procedures and resecting the tumour prior to commencement of CPB or avoiding the use of bypass completely these effects

are minimised which may improve the long-term survival.

Anatomical lobectomy or pneumonectomy was the preferred resection for lung cancer in the present series. Some authors have questioned whether such radical surgery is necessary having demonstrated comparable survival rates for lobectomy and wedge excision in small peripheral lung carcinoma [36]. A limited resection has particular appeal in patients with reduced pulmonary function, low cardiac reserve or who have sustained the insult of a simultaneous cardiac surgical procedure. More recent prospective trials have favoured lobectomy over limited resections demonstrating survival advantage and reduced incidence of loco-regional recurrence in patients with peripheral T1N0 non-small cell lung cancer; we have thus favoured this approach [37].

The predicted survival following lung resection is in part determined by the nodal status of the tumour and the principal benefit of lymphadenectomy is in accurate staging of the disease. Whether a radical systematic mediastinal lymphadenectomy confers a survival advantage compared with that of a lesser dissection of the lymph nodes is less clear. Furthermore a radical dissection prolongs the operating time and increases the morbidity [38]. We routinely removed bronchopulmonary (station 11, 12) and hilar nodes (station 10), subcarinal nodes (station 7) [39] were removed only if accessible. In the absence of controlled trials it is difficult to evaluate the long-term survival in patients with lung cancer who have undergone simultaneous procedures. In the previous published series the patient numbers tended to be small with variability in the tumour stage and the surgical treatment employed. As a result definitive conclusions regarding survival are not possible. Although some authors have demonstrated 5-year survival rates of 40–80%, comparable with isolated pulmonary resection [17–19], others have had a less favourable experience [14,16]. In the present series cancer free survival was determined by the tumour stage, with poor survival in patients with T3 tumours. Nevertheless in carefully selected patients simultaneous pulmonary resection with cardiac surgery is possible with an acceptable operative mortality (0–6.5%) and offers the patient a potential chance of cure.

4.1. Conclusions

From this personal experience and a review of the literature we conclude that simultaneous pulmonary resection and cardiac surgery can be safely performed with adequate cancer free survival in patients with stage 1 or stage 11 pulmonary neoplastic disease. Early cancer recurrence and poor long-term survival was principally determined by the primary tumour stage. Patients with advanced tumours (T3) and those requiring complex resections of the chest wall may have a less favourable outcome and not suitable for this type of surgery. Avoidance of CPB is possible in selected patients with suitable coronary anatomy and may

decrease the operative morbidity, by reducing post operative blood loss and mechanical ventilation requirements.

References

- [1] Patel RL, Townsend ER, Fountain SW. Elective pneumonectomy: Factors associated with morbidity and operative mortality. *Ann Thorac Surg* 1992;54:84–88.
- [2] Van Miegham W, Coolen L, Malysse I, Lacquet LM, Deneffe GJ, Demedts MG. Amiodarone and the development of ARDS after lung surgery. *Chest* 1994;105:1642–1645.
- [3] Naruke T, Goya T, Tsuchiya T, Sulmasu K. Prognosis and survival in resected lung carcinoma based on the new International Staging System. *J Thorac Cardiovasc Surg* 1988;96:440–447.
- [4] Foster ED, Davis KB, Carpenter JA, Abele S, Fray D. Risk of non cardiac operation in patients with defined coronary artery disease: The coronary artery surgery study (CASS) registry experience. *Ann Thorac Surg* 1986;41:42–50.
- [5] Thomas P, Giudicelli R, Guillen JC, Fuentes P. Is lung cancer surgery justified in patients with coronary artery disease?. *Eur J Cardiothorac Surg* 1994;8:287–292.
- [6] Naunheim KS, Fiore AC, Wadley J. The changing mortality of myocardial revascularisation: coronary artery bypass and angioplasty. *Ann Thorac Surg* 1988;46:666–674.
- [7] Dalton ML, Parker TM, Mistrot J, Bricker DL. Concomitant coronary artery bypass and major noncardiac surgery. *J Thorac Cardiovasc Surg* 1978;75:621–624.
- [8] Bricker DL, Parker TM, Dalton ML, Mistral JJ. Open heart surgery with concomitant pulmonary resection. *Bull Texas Heart Inst* 1980;7:411–419.
- [9] Girardet RE, Marsi ZM, Lansing AM. Pulmonary lesions in patients undergoing open heart surgery: approach and management. *J Kentucky Medical Assoc* 1981;79:645–648.
- [10] Piehler JM, Ttastek VF, Pairolero PC, et al. Concomitant cardiac and pulmonary operations. *J Thorac Cardiovasc Surg* 1985;90:662–667.
- [11] Hura DE, Brahos GJ. Aortocoronary bypass and concomitant resection for carcinoma of the lung. *Contemporary surgery* 1987;31:11–14.
- [12] Canver CC, Bhayana JN, Lajos TZ, et al. Pulmonary resection combined with cardiac operations. *Ann Thorac Surg* 1990;50:796–799.
- [13] Ulicny KS, Schmelzer V, Flege JB, et al. Concomitant cardiac and pulmonary operation: The role of cardiopulmonary bypass. *Ann Thorac Surg* 1992;54:289–295.
- [14] Yokoyama T, Derrick M, Lee A. Cardiac operation with associated pulmonary resection. *J Thorac Cardiovasc Surg* 1993;105:912–915.
- [15] Rosalion A, Woodford NW, Clarke CP, Buxton B. Concomitant coronary revascularization and resection of lung cancer. *Aust N Z J Surg* 1993;63:336–340.
- [16] Miller DL, Orszulak TA, Pairolero PC, Trastek VF, Schaff HV. Combined operation for cancer and cardiac disease. *Ann Thorac Surg* 1994;58:989–993.
- [17] La Francesca S, Frazier OH, Radovancevic B, De Caro LF, Reul GJ, Cooley DA. Concomitant cardiac and pulmonary operations for lung cancer. *Texas Heart Inst J* 1995;22:296–300.
- [18] Butee de la Riviere A, Knaeper P, Van Swieten H, Vanderswchueren R, Ernst J, Van den Bosch J. Concomitant open heart surgery and pulmonary resection for lung cancer. *Eur J Cardio-thorac Surg* 1995;9:310–314.
- [19] Rao V, Todd TRJ, Weisel RD, et al. Results of combined pulmonary resection and cardiac operation. *Ann Thorac Surg* 1996;62:342–347.
- [20] Yellin A, Moshkovitz Y, Simanski DA, Mohr R, Hashomer T. Coronary revascularisation and pulmonary lobectomy without cardiopulmonary bypass. *J Thorac Cardiovasc Surg* 1994;108:797–798.
- [21] Urschel HC, Razzuk MA. Median sternotomy as the standard approach for pulmonary resection. *Ann Thorac Surg* 1986;41:130–134.
- [22] Cooper JD, Nelem JM, Pearson FG. Extended indications for median sternotomy in patients requiring pulmonary resection. *Ann Thorac Surg* 1978;26:413–420.
- [23] Harker LA. Bleeding after cardiopulmonary bypass. *New Engl J Med* 1986;314:1446–1447.
- [24] Harker LA, Malpass TW, Branson HE, Hessel EA, Slichter SJ. Mechanism of abnormal bleeding in patients undergoing cardiopulmonary bypass: acquired transient platelet dysfunction associated with selective alpha granule release. *Blood* 1980;56:824–834.
- [25] Buffolo E, Andrade JCS, Branco INR, Agviar LF, Ribeiro EE, Jatene AD. Myocardial revascularization without extracorporeal circulation. *Eur J Cardiothorac Surg* 1990;4:504–508.
- [26] Ito H, Hamano K, Gohra H, et al. Relationship between respiratory distress and cytokine response after cardiopulmonary bypass. *Surg Today* 1997;27:220–225.
- [27] Kirklin JW. Guidelines and indications for coronary artery bypass surgery. *J Am Coll Cardiol* 1991;17:543–589.
- [28] Moshkovitz Y, Mohr R. Coronary artery bypass without cardiopulmonary bypass—the pros and the cons. *Isr J Med Sci* 1993;29:716–720.
- [29] Habib RH, Zacharias A, Engoren M. Determinants of prolonged mechanical ventilation after coronary artery bypass grafting. *Ann Thorac Surg* 1996;62:1164–1171.
- [30] Gu YJ, de Vries AJ, Boonstra PW, van Oeveren W. Leukocyte depletion results in improved lung function and reduced inflammatory response after cardiac surgery. *J Thorac Cardiovasc Surg* 1996;112:494–500.
- [31] Canver CC, Marrin CA, Plume SK, Nugent WC. Should a patient with a treated cancer be offered an open heart operation. *Ann Thorac Surg* 1993;55:1202–1204.
- [32] Markewitz A, Faist E, Lang S, Hultner L, Weinhold C, Reichart B. An imbalance in T-helper cell subsets alters immune response after cardiac surgery. *Eur J Cardio-thorac Surg* 1996;10:61–67.
- [33] Knudsen F, Anderson L. Immunological aspects of cardiopulmonary bypass. *J Cardiothorac Anesth* 1990;4:245–258.
- [34] Jensen RH, Storgaard M, Vedelsdal R, Obel N. Impaired neutrophil chemotaxis after cardiac surgery. *Scand J Thorac Cardiovasc Surg* 1995;29:115–118.
- [35] Markewitz A, Faist E, Weinhold C, Lang S, Endres S, Hultner L, Reichart B. Alterations of cell-mediated immune response following cardiac surgery. *Eur J Cardiothorac Surg* 1993;7:193–199.
- [36] Hoffmann T, Ransdell H. Comparison of lobectomy and wedge resection for carcinoma of the lung. *J Thorac Cardiovasc Surg* 1980;79:211–217.
- [37] Ginsberg R, Rubinstein L. Randomised trial of lobectomy versus limited resection for T1 N0 non small cell lung cancer. *Ann Thorac Surg* 1995;60:615–623.
- [38] Izbicki J, Thetter O, Habeko M, Kary O, et al. Radical systematic mediastinal lymphadenopathy in non small cell lung cancer: a randomised trial. *Br J Surg* 1994;81:229–235.
- [39] Naruke T, Suemasu K, Ishikawa S. Lymph node mapping and the curability at various levels of metastasis in resected lung cancer. *J Thorac Cardiovasc Surg* 1978;76:832–839.

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