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CLINICAL REPORT

Perioperative management of carinal pneumonectomy: a retrospective review of 13 patients

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Abstract Carinal pneumonectomy is a challenging procedure because of the difficulties in surgical technique, intraoperative airway management, and postoperative respiratory and anastomotic complications. However, information regarding the anesthetic and intraoperative respiratory management of this procedure is scarce. This report describes our routine anesthetic and respiratory management strategy in patients undergoing carinal pneumonectomy. Medical records of 13 patients who underwent carinal pneumonectomy under combined general and epidural anesthesia between 2008 and 2012 were analyzed retrospectively. Eleven patients underwent right carinal pneumonectomy and two underwent left carinal pneumonectomy. A left double-lumen tube was used in all but one case, in which endobronchial intubation was difficult because of intrabronchial invasion of the tumor. A 6.0-mm-long reinforced endobronchial tube was intubated into the main bronchus of the non-operative side from the surgical field during carinal resection. There were no episodes of severe hypoxemia or hypercapnia during surgery. Twelve patients were extubated immediately after surgery. No patient developed post-thoracotomy acute lung injury or required postoperative reintubation despite poor preoperative respiratory function. The 30-day mortality rate was 0 %. Our airway management protocol for carinal pneumonectomy enables positive surgical outcomes.

Keywords Carinal pneumonectomy · Airway management · Thoracic anesthesia

Introduction

Carinal pneumonectomy, a combination of pneumonectomy and carinal resection and reconstruction, is performed for patients with lung or mediastinal cancer involving the carina [1]. Superior vena cava (SVC) replacement [2] or partial resection of the left atrium [3] is often additionally performed. Carinal pneumonectomy is a challenge for surgeons and anesthesiologists, because of complicated operative technique, airway management, and postoperative respiratory and anastomotic complications. According to recent reports, the incidence of operative mortality is approximately 5 % [4]. Close cooperation between surgeons and anesthesiologists is essential for specific airway management during the procedure. Assuring a good surgical field is mandatory for facilitating bronchial anastomoses. As far as we are aware, no case series exists focusing on airway management in patients undergoing carinal pneumonectomy. Therefore, we report our experience with 13 carinal pneumonectomy cases, and discuss the usefulness of our perioperative anesthetic and airway management protocol developed by thoracic surgeons and anesthesiologists at Juntendo University Hospital.

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Case series

After obtaining approval from the hospital Institutional Ethics Committee (research number 12–191), medical, anesthetic, and surgical records of 13 patients who underwent carinal pneumonectomy from May 2008 to July 2012 at Juntendo University Hospital were reviewed retrospectively.

The patients were mostly men. ASA physical status was I in three patients and II in ten patients. Based on preoperative spirometry, the predicted postoperative forced expiratory volume in 1 s (ppo %FEV1) was less than 30 % in one patient. There were seven patients whose predicted postoperative diffusion capacity of carbon monoxide (ppo %DLCO) was less than 30 % (Table 1). Preoperative diagnoses were lung cancer in 11 patients and mediastinal tumor in two patients.

Right carinal pneumonectomy was performed through a right thoracotomy with a posterolateral incision in the left lateral decubitus position in 11 patients. Left carinal pneumonectomy was performed through a left thoracotomy with a posterolateral incision in one patient (patient #11), and left thoracotomy with a posterolateral incision, followed by sternotomy in the supine position in one patient (patient #2). SVC replacement was additionally performed in two patients (patients #10 and #13) and partial left atrial resection was performed in two patients (patients #8 and #12). In addition, basic intraoperative monitoring (BIS) and invasive arterial pressure were monitored. Central venous catheters through the femoral vein were inserted in six patients (# 1, 5, 6, 8, 11, 13) undergoing clamping of the SVC or innominate vein. Combined general and epidural anesthesia was performed on all patients. The epidural catheter was inserted between the 5th and 8th thoracic interspaces before induction of general anesthesia. Total intravenous anesthesia (TIVA) using fentanyl, remifentanil, and propofol was used. Propofol was administered using a target-controlled infusion to achieve 40–60 BIS level. A combination of opioids (fentanyl, 200–500 μg/day, or morphine, 2–4 mg/day) and local anesthetics (0.25 % levobupivacaine or 0.2–375 % ropivacaine) were administered through the epidural catheter for perioperative analgesia. The amount of intravenous fluid administered was restricted to below 6 mg/kg/h.

Endotracheal intubation was performed on all patients. Basically, a left DLT was used for right carinal pneumonectomy and a right DLT for left carinal pneumonectomy. However, in case #11, a bronchial blocker through a single-lumen tube was used, because the DLT was not suitable due to tumor invasion of the bronchus. Details of the routine airway management for carinal pneumonectomy are described later.

Protective One Lung Ventilation (OLV) [5], consisting of a low tidal volume (200–350 ml), positive end-expiratory pressure (4–6 cmH_2O), and pressure controlled ventilation (peak inspiratory pressure 13–18 cmH_2O), was used. Respiratory rate and inspiratory-to-expiratory time ratio were 12–15/min and 1:1.5–1:2. SpO_2 was maintained above 90 % in all but one case, in which SpO_2 decreased to 88 % for about 15 min. Although a high-frequency jet

Table 1 Preoperative data

	Age (years)	Gender (F/M)	Height (cm)	Weight (kg)	Brinkman index	%VC	FEV1/ FVC (%)	ppo % FEV1 (%)	ppo % DLCO (%)	Pao_2 (mmHg)	$Paco_2$ (mmHg)
1	60	M	169	57	1,200	101.1	83.8	48.8	33.9	90.2	40.5
2	69	M	167	68	400	123.4	61.4	47.9	NA	85.9	43.9
3	73	M	170	60	4	54.2	55.1	45.5	13.7	70.6	38.4
4	66	M	164	61	1,200	105.5	77.6	50.2	18.7	74.3	35.8
5	44	M	171	63	720	74.4	80	32.5	NA	82.4	44.8
6	43	F	154	42	0	69.3	79.5	31.9	NA	95.4	40.7
7	58	M	172	62	1,080	53.4	87	31.1	30.7	69.2	48.9
8	68	M	171	55	1,200	76.6	56.6	33.4	28.2	101.9	39.8
9	67	M	155	47	1,200	52.4	70.1	22.1	10.4	70.1	38.9
10	66	M	163	77	1,600	87.2	64	33.6	23.3	74.3	35.4
11	78	F	142	47	0	52.6	79.5	61.0	NA	78	29.4
12	68	M	165	56	1,500	109.7	56.4	34.6	19.9	94	34.9
13	70	M	173	76	1,680	95.9	76.2	36.9	29.2	61.9	34.0
Mean	63.9		164.4	59.3	906	81.2	71.3	39.2	23.1	80.6	38.9
SD	10.3		9.1	10.4	616	24.5	11.3	10.6	8.1	12.1	5.2

%VC vital capacity as percent of predicted, *FEV1* forced expiratory volume in one second, *FVC* forced vital capacity, *ppo %FEV1* predicted postoperative forced expiratory volume in one second, *ppo %DLCO* predicted postoperative diffusion capacity of carbon monoxide, *F* female, *M* male; *NA* not available, *SD* standard deviation

ventilator and cardiopulmonary bypass machine were at hand for emergencies in the operation room, neither of them was used.

Intraoperative airway management of right carinal pneumonectomy was performed as follows. After subcarinal nodal dissection, a sterile, extra-long, flexible, armored, single-lumen, 6-mm endobronchial tube and 9-mm connecting tube (Phycon endobronchial tube, Fuji Systems, Tokyo, Japan) were prepared before starting carinal resection. The left DLT was withdrawn up to the trachea after hyperventilation, to achieve a $PETCO_2$ of approximately 25–30 mmHg. Then, the left main bronchus was incised and anchored with sutures, and the extra-long tube was inserted across the surgical field.

After achieving stability of ventilation with the tube across the surgical field, the proximal side of the trachea was separated and the carina and right lung were removed. The endobronchial tube was intermittently withdrawn and advanced, to facilitate suturing during airway re-approximation. Once two-thirds of the suturing had been achieved, the endobronchial tube was withdrawn from across the surgical field. Under direct visualization, the DLT was advanced into the bronchus beyond the anastomosis, and the remaining part of the suturing was performed. During this procedure, the DLT was advanced a little more deeply to prevent the bronchial cuff from being damaged by the sutures. During the air leakage test, the bronchial cuff was deflated to detect leakage from the anastomosis and stump.

For left carinal pneumonectomy, a right DLT was used. Obstruction of the right upper bronchus was carefully avoided when the endobronchial tube was inserted across the surgical field.

One of the patients, (patient #2) who was originally scheduled to undergo left upper lobectomy, unexpectedly required left carinal pneumonectomy due to tumor invasion. In this patient, the left DLT was extubated and a long 26-Fr single reinforced tube was orally inserted into the trachea, while the right lung was ventilated with the tube across the surgical field. After the anastomosis between the trachea and bronchus, the tube was inserted into the right main bronchus.

The intraoperative data of the 13 patients are shown in Table 2. At the end of the surgery, the DLT was exchanged for a laryngeal mask airway (LMA) or single-lumen tube to allow observation of the anastomosis and stump with a larger diameter bronchoscope. All but one patient (#13) were extubated in the operating room. Patient #13 was extubated 11 h after surgery because of hypothermia (rectal temperature of 34.7 °C). Postoperative atrial fibrillation occurred in two patients (#3, 9), and ileus occurred in one patient (#1). None of the patients required reintubation. The 30-day operative mortality rate was 0 %.

Discussion

The mortality rate following carinal pneumonectomy is reportedly higher than that following simple carinal resection [6]. One of the reasons for the higher mortality may be the higher incidence of post-thoracotomy acute lung injury (ALI) with carinal pneumonectomy as compared to simple carinal resection [7, 8].

Licker et al. [9] stated that restriction of intraoperative fluid administration to below 1,500 ml leads to prevention of development of acute respiratory distress syndrome (ARDS). In our case series, the amount of intravenous fluid administered was 1,492 ± 478 ml. Restrictive fluid management may thus have contributed to the better outcome in our patients.

Generally, it has been shown that a preoperative FEV1 of 2 l or %FEV1 of over 80 % decreases the incidence of postoperative respiratory and cardiac complications in patient undergoing pneumonectomy [10]. A ppo %FEV1 of below 40 % may increase the incidence of postoperative cardiac complications and mortality, while a ppo %FEV1 below 30 % may increase mortality or the need for postoperative mechanical ventilation in patients undergoing pneumonectomy [11]. Although the overall average FEV1 was below 2.0 l and ppo %FEV1 was below 40 % in eight patients in our study (Table 1), none of the patients suffered postoperative cardiac complications or needed mechanical ventilation. This may be partly due to the relatively short duration of surgery in our cases (Table 2). Furthermore, since a low FEV1 preoperatively may be reflective of atelectasis of the lung that is to be resected, the function of the remaining lung may be close to normal. Carinal pneumonectomy is performed as salvage surgery; currently, there is no consensus about the relevance of surgical indications and preoperative evaluation to the outcome of the procedure. Further, since carinal pneumonectomy is more invasive than simple pneumonectomy, because of additional bronchoplasty, better preoperative respiratory function may be more desirable in this procedure than in simple pneumonectomy.

Thoracic epidural anesthesia (TEA) may contribute to improving the outcome of carinal pneumonectomy. TEA has been shown to decrease the incidence of respiratory complications [12]. The other advantages of postoperative TEA with opioids include promotion of circulatory stability due to inhibition of thoracic sympathetic activity [13], reduction of fluid demand, early ambulation, and postural drainage resulting from the satisfactory postoperative analgesia [14, 15].

In our institution, TIVA is used for carinal pneumonectomy because it enables maintenance of a stable depth of anesthesia despite interruption of ventilation during manipulation of the endobronchial tube. TIVA also maintains good oxygenation during OLV [16]. Further, propofol

Table 2 Intraoperative data

	Lowest FiO_2	Extubation (Y/N)	Crystalloid (ml)	Colloid (ml)	Transfusion (ml)	EBL (ml)	Urine (ml)	Anesthesia (min)	Surgery (min)
1	0.8	Y	2,450	1,000	0	430	1,215	470	340
2	1	Y	2,600	750	0	400	730	560	460
3	0.8	Y	1,180	1,500	560	565	900	450	335
4	0.55	Y	950	500	0	230	190	312	238
5	0.4	Y	1,450	200	420	660	255	460	325
6	0.6	Y	1,760	1,000	0	650	760	390	267
7	1	Y	2,250	500	560	970	355	571	430
8	1	Y	1,050	1,250	0	780	780	358	256
9	1	Y	1,400	650	0	150	750	382	302
10	1	Y	3,200	500	1,840	2,300	950	641	538
11	0.55	Y	1,510	0	0	135	210	279	345
12	0.68	Y	1,860	1,000	280	665	590	391	465
13	1	N	2,850	750	1,600	1,510	2,840	420	523
Mean	0.80		1,885	738	405	727	810	437	371
SD	0.22		723	414	626	600	605	104	101

Fio_2 fraction of inspiratory oxygen, *Y* yes, *N* no, *EBL* estimated blood loss, *SD* standard deviation

may be advantageous for preventing postoperative nausea and vomiting [17], and improving the quality and time to awakening [18] following such invasive surgery.

In conclusion, 13 patients undergoing carinal pneumonectomy were successfully managed by our anesthesia and airway management protocol. There were no episodes of severe hypoxemia or hypercapnia intraoperatively. All but one of the patients were successfully extubated immediately after surgery.

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