Original Article

Effect of small body habitus on peri-operative outcomes after robotic-assisted pulmonary lobectomy: retrospective analysis of 208 consecutive cases

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Background: Patients with smaller body surface area (BSA) have smaller pleural cavities, which limit visualization and instrument mobility during video-assisted thoracoscopic surgery (VATS). We investigated the effects of BSA on outcomes with robotic-assisted VATS lobectomy.

Methods: We analyzed 208 consecutive patients who underwent robotic-assisted lobectomy over 34 months. Patients were separated into group A (BSA ≤1.65 m^2) and group B (BSA >1.65 m^2). Operative times, estimated blood loss (EBL), conversions to thoracotomy, complications, hospital length of stay (LOS), and in-hospital mortality were compared.

Results: Group A had 40 patients (BSA 1.25–1.65 m^2), and group B had 168 patients (BSA 1.66–2.86 m^2). Median skin-to-skin operative times [± standard error of the mean (SEM)] were 169±16 min for group A and 176±6 min for group B (P=0.34). Group A had median EBL of 150±96 mL compared to 200±24 mL for group B (P=0.37). Overall conversion rate to thoracotomy was 8/40 (20.0%) in group A versus 12/168 (7.1%) in group B (P=0.03); while emergent conversion for bleeding was 2/40 (5.0%) in group A versus 5/168 (3.0%) in group B (P=0.62). Postoperative complications occurred in 12/40 (30.0%) in group A, compared to 66/168 (39.3%) in group B (P=0.28). Patients from both groups had median hospital LOS of 5 days (P=0.68) and had similar in-hospital mortality.

Conclusions: Patients with BSA ≤1.65 m^2 have similar perioperative outcomes and complication risks as patients with larger BSA. Patients with BSA ≤1.65 m^2 have a higher overall conversion rate to thoracotomy, but similar conversion rate for bleeding as patients with larger BSA. Robotic-assisted pulmonary lobectomy is feasible and safe in patients with small body habitus.

Keywords: Lung cancer; robotic; lobectomy; body surface area (BSA)

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Introduction

Mosteller simplified calculation of body surface area (BSA) in metric terms: BSA equals the square root of the product of weight (in kg) times height (in cm) divided by 3,600 (1). BSA is widely used as the biometric unit for normalizing physiologic parameters (cardiac output, left ventricular mass, renal clearance) and for determination of appropriate drug dosages in cancer chemotherapy in individuals of different body size (2). However, BSA is not a reliable indicator of distribution of fat and adipose tissue, which constitute distribution volumes for lipophilic and hydrophilic chemotherapy agents, respectively (3). The importance of BSA in surgery is related to tissue sizes and operative field exposure.

Smaller body habitus has been associated with increased morbidity in cardiothoracic surgery due to limited access to the surgical field and to small caliber vascularity. In carotid artery endarterectomies, shorter height and smaller BSA were associated with greater operative risk of stroke and death (4).

Patients with smaller BSA have smaller pleural cavities, which limit visualization and instrument mobility during video-assisted thoracoscopic surgery (VATS). Robotic-assisted surgery provides the surgeon a handful of advantages, including a 3-dimensional view of the operating field, better control of instrumentation, capacity to reduce hand-related tremors, and flexibility of instruments with seven directions of articulation, making dissection more precise and accurate (5). However, smaller BSA could result in internal and external collisions between the arms of the robotic patient cart. We investigated the effects of BSA on perioperative outcomes related to robotic-assisted VATS lobectomy.

Methods

We retrospective analyzed prospectively collected data from 211 consecutive patients undergoing robotic-assisted pulmonary lobectomy by one surgeon over a 34-month period from September 2010 through May 2013 at our institution. All our patients gave informed consented for our standard surgical procedure, which consisted of fiberoptic bronchoscopy, video-assisted thoracoscopic insertion of tunneled extrapleural intercostal regional analgesia infusion catheter, robotic-assisted video-thoracoscopic wedge resection and/or robotic-assisted video-thoracoscopic (completion) lobectomy, and mediastinal lymph node dissection, with possible thoracotomy.

Three patients were converted to pneumonectomy and were excluded from the study cohort. We investigated the difference in surgical outcomes between group A, BSA $\leq$1.65 m^2, and group B, BSA >1.65 m^2. Operative times, estimated blood loss (EBL), conversion rates to open lobectomy, clinically significant perioperative complication rates, chest tube duration, hospital length of stay (LOS), and in-hospital mortality were noted.

Clinically significant intraoperative and postoperative complications were recorded and compared, including pulmonary embolism, respiratory failure, hemothorax, chyle leak, pneumothorax or mucus plug that required intervention, air leaks persisting more than 7 days, aspiration events, atrial fibrillation, cardiovascular events, and death. An extensive literature review was then performed on effects of BSA on perioperative outcomes after thoracotomy and VATS cases.

Mean, standard error of the mean (SEM), and range were used to report continuous and ordinal variables, such as age, BSA, and body mass index (BMI). Median ± SEM was used for descriptive variables, such as operative times, EBL, chest tube duration, and hospital LOS. We used Student's *t*-test, χ^2, or Fisher's exact test, as appropriate to compare variables mentioned above. Statistical significance was established at $P \leq 0.05$.

This study was conducted in accordance with the amended Declaration of Helsinki as outcomes research for quality assurance as part of our departmental thoracic oncology clinical research database protocol. This protocol was approved by our Scientific Review Committee (MCC #16512) and by our affiliated university Institutional Review Board (IRB #Pro00002678), which waived informed consent for this retrospective study, which is considered as review of existing data. Nevertheless, all patients gave informed consent for our standard surgical procedure, as previously described. Some patients also gave informed consent for any anticipated en bloc chest wall and/or vertebral resection, with possible reconstruction. Through our institutional surgical informed consent, patients gave permission to use surgery-related and tissue-related data for education and research purposes.

Results

Prior to analyzing our cohort, we observed internal and external collisions of the robotic patient cart arms in patients who weighed 60 kg or less. We hypothesized that these observed collisions were due to decreased distances between robotic arms, which was related to smaller pleural

Table 1 Patients' demographic characteristics

Clinical variable	BSA ≤1.65 m^2 (n=40)	BSA >1.65 m^2 (n=168)	P value
BSA (m^2)*	1.57±0.01 (range, 1.25–1.65)	1.96±0.02 (range, 1.66–2.86)	–
Age (years)*	68.5±1.5 (range, 50–85)	68.0±0.8 (range, 29–86)	0.20
Sex (M/F)	3/37 (8%/92%)	96/72 (57%/43%)	<0.0001
BMI (kg/m^2)*	22.3±0.5 (range, 14–29)	28.0±0.5 (range, 19–59)	<0.0001

*, mean ± SEM. BSA, body surface area; BMI, body mass index; SEM, standard error of the mean.

Table 2 Intraoperative complications

Clinical variable	BSA ≤1.65 m^2 (n=40, %)	BSA >1.65 m^2 (n=168, %)	P value
Total intraoperative complications	5 (12.5)	13 (7.7)	0.35
Bleeding from PA	3 (7.5)	4 (2.4)	0.13
Bleeding from PV	0 (0.0)	3 (1.8)	1.00
Minor bleeding	0 (0.0)	1 (0.6)	1.00
Phrenic nerve injury	0 (0.0)	1 (0.6)	1.00
Recurrent laryngeal nerve injury	1 (2.5)	1 (0.6)	0.35
Bronchial injury	1 (2.5)	2 (1.2)	0.47
Diaphragm injury	0 (0.0)	1 (0.6)	1.00
Overall conversion to open lobectomy	8 (20.0)	12 (7.1)	0.03
Urgent conversion due to bleeding	2 (5.0)	5 (3.0)	0.62

BSA, body surface area; PA, pulmonary artery; PV, pulmonary vein.

cavities and chest wall areas in these patients. Using BSA as surrogate for chest wall area, we hypothesized that perioperative outcomes may differ between patients with small BSA and with larger BSA.

We identified patients who weighed 60 kg and found that their mean BSA was 1.65 m^2. We thus divided our cohort of 208 patients into two groups: group A, n=40 patients (BSA =1.25–1.65 m^2), and group B, n=168 patients (BSA =1.66–2.86 m^2). Our cohort demographics are shown in *Table 1*. Group A had mean age 68.5±1.5 years (range, 50–85 years); group B had mean age 68.0±0.8 years (range, 29–86 years). Patients with BSA ≤1.65 m^2 have a higher proportion of women than do patients with larger BSA, and BMI was significantly greater in patients with BSA >1.65 m^2.

Intraoperative complication rates did not significantly differ between the two BSA groups. Our overall conversion-to-thoracotomy rate was significant higher for group A, 20%, compared to 7.1% for group B (P=0.03), but emergent conversion rates for bleeding were similar, with 2/40 (5.0%) in group A versus 5/168 (3.0%) in group B (P=0.62) (*Table 2*).

Major intraoperative outcomes, such as EBL and skin-to-skin operative times, were similar between groups. Group A had median EBL of 150±96 mL compared to 200±24 mL for group B (P=0.37). Median skin-to-skin operative times were 169±16 min for group A and 176±6 min for group B (P=0.34). Both groups had median hospital LOS of 5± SEM days and had no difference in in-hospital mortality (*Table 3*).

Minor and/or major postoperative complications occurred in 12/40 (30.0%) in group A, compared to 66/168 (39.3%) in group B (P=0.28). The most common postoperative complications in group A were prolonged air leaks for more than 7 days in 7/40 (17.5%), atrial fibrillation in 3/40 (7.5%), and pneumonia in 2/40 (5.0%), while the most common complications in group B were prolonged air leak in 28/168 (16.7%; P=1.0), atrial fibrillation in 22/168 (13.1%; P=0.42), and pneumonia in 18/168 (10.7%; P=0.38) (*Table 4*).

Discussion

Our perioperative outcomes are comparable with those previously described for robotic-assisted surgery. Our overall complication rates were 30% and 39% for patients with small BSA and with large BSA, respectively, and our in-hospital mortality rates were 0% and 2%, respectively.

Table 3 Perioperative outcomes

Clinical variable	BSA ≤1.65 m^2 (n=40)	BSA >1.65 m^2 (n=168)	P value
Skin-to-skin duration (min)*	168.5±16 (range, 81–477)	176±6 (range, 88–515)	0.34
EBL (mL)*	150±96 (range, 25–3,500)	200±24 (range, 25–2,800)	0.37
Chest tube duration (days)*	4.0±1.2 (range, 2–32)	4.0±0.64 (range, 1–90)	0.62
Hospital LOS (days)*	5.0±0.96 (range, 2–33)	5.0±0.39 (range, 2–32)	0.68
In-house mortality	0 (0.0%)	3 (1.8%)	1.00

*, median ± SEM. BSA, body surface area; EBL, estimated blood loss; LOS, length of stay.

Table 4 Postoperative complications

Clinical variable	BSA ≤1.65 m^2 (n=40, %)	BSA >1.65 m^2 (n=168, %)	P value
Postoperative complications (major and minor)	12 (30.0)	66 (39.3)	0.28
Prolonged air leak for ≥7 days	7 (17.5)	28 (16.7)	1.00
Aspiration	0 (0.0)	5 (3.0)	0.59
Pneumonia	2 (5.0)	18 (10.7)	0.38
Mucous plug requiring intervention	1 (2.5)	13 (7.7)	0.31
Respiratory failure	0 (0.0)	4 (2.4)	1.00
Pneumothorax requiring intervention	0 (0.0)	4 (2.4)	1.00
Hemothorax	0 (0.0)	5 (3.0)	0.59
Pleural effusion	0 (0.0)	2 (1.2)	0.59
Chyle leak	1 (2.5)	2 (1.2)	0.47
Atrial fibrillation	3 (7.5)	22 (13.1)	0.42
Other arrhythmias	0 (0.0)	2 (1.2)	0.59
Pulmonary embolism	0 (0.0)	2 (1.2)	0.59

BSA, body surface area.

Our patients with small BSA and with large BSA had EBL of 150 and 200 mL, respectively, skin-to-skin operative times of 169 and 176 min, respectively, overall conversion-to-thoracotomy rates of 20.0% and 7.1%, respectively, and hospital LOS of 5 and 5 days, respectively.

A systematic review of robotic-assisted VATS lobectomy literature reported overall morbidity rates between 10% and 39%, with perioperative mortality rates between 0% and 3.8% (6). A meta-analysis of currently available robotic literature, including data from 326 patients, showed a pooled average operative time of 215 min, overall conversion rate of 9.4%, mortality rate of 2.1%, and hospital LOS of 6 days (7). Park and colleagues published one of the largest series on robotic-assisted pulmonary lobectomy, with median operative time of 206 min, conversion-to-open rate of 8%, overall mobility rate of 25%, and median hospital LOS of 5 days (8).

How has BSA related to outcomes in other clinical scenarios? In transplant surgery, recipients with a higher (graft kidney volume):(recipient BSA) ratio had better graft function than those with lower ratios at 1 and 6 months post-transplantation (9). Both female gender and small BSA are associated with higher degrees of hemodilution during cardiac bypass, which may directly deteriorate outcomes and lead to transfusions as a result of low hemoglobin levels during and after the operation (10). Komoda *et al.*, revealed that adult candidates for heart transplant with lower BSA, including most female patients, had worse prognosis on the waiting list after progression to critically ill status (11). Patients with smaller BSA have worse outcomes after various cardiovascular interventions due to smaller size and calibers of their vascularity (4). In contrast, completion of laparoscopic colorectal procedures may be more technically challenging and time consuming in large BSA patients (12).

Using BSA as surrogate for chest wall area and the operative field during thoracoscopic surgery, our study investigated the relationship between BSA and perioperative outcomes of robotic-assisted VATS lobectomy. Robotic instrumentation provides more degrees of freedom to the surgeon to perform difficult resections. In our experience, smaller operative fields resulted in problems with robotic arms colliding and making robotic-assisted VATS surgery more challenging, as confirmed by greater overall conversion-to-thoracotomy rates in patients with smaller BSA. However, even though smaller BSA represents a challenge in manipulation of robotic instrumentation, perioperative outcomes after robotic-assisted VATS lobectomy did not seem to be worsened by smaller BSA.

Conclusions

Patients with BSA≤1.65 m^2 have a higher proportion of women and have lower BMI than patients with larger BSA. While patients with BSA ≤1.65 m^2 have higher overall conversion rates than patients with larger BSA, emergent conversion rates for bleeding is similar between the two BSA groups. Moreover, smaller BSA patients have similar operative times, EBL, overall intraoperative complications, overall postoperative complications, chest tube days, hospital LOS, and in-hospital mortality rates as patients with larger BSA. Our study suggests that robotic-assisted pulmonary lobectomy is feasible and safe in patients with small body habitus.

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Footnote

Conflicts of Interest: Eric M. Toloza and Jacques-Pierre Fontaine had financial relationships with Intuitive Surgical Corporation in form of honoraria as robotic thoracic surgery proctors and observation sites. This paper is an update of previous Oral Presentations at the 51st Annual Meeting of the Eastern Cardiothoracic Surgical Society, Clearwater, FL, October 24, 2013, and at the 1st Annual World Robotic Symposium of the Society of Robotic Surgery, Lake Buena Vista, FL, November 9, 2013.

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