Original Article

Short-term outcomes of robotic-assisted transthoracic diaphragmatic plication

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Background: Patients who are symptomatic from diaphragmatic dysfunction may benefit from diaphragmatic plication. We recently modified our plication approach from open thoracotomy to robotic transthoracic. We report our short-term outcomes.

Methods: We conducted a single-institution retrospective review of all patients who underwent transthoracic plications from 2018, when we began using the robotic approach, to 2022. The primary outcome was short-term recurrence of diaphragm elevation with symptoms noted before or during the first planned postoperative visit. We also compared proportions of short-term recurrences in patients that underwent plication with extracorporeal knot-tying device alone versus those that used intracorporeal instrument tying (alone or supplemental). Secondary outcomes included subjective postoperative improvement of dyspnea at follow-up visit and by postoperative patient questionnaire, chest tube duration, length of stay (LOS), 30-day readmission, operative time, estimated blood loss (EBL), intraoperative complications, and perioperative complications.

Results: Forty-one patients underwent robotic-assisted transthoracic plication. Four patients experienced recurrent diaphragm elevation with symptoms before or during their first routine postoperative visit, occurring on POD 6, 10, 37, and 38. All four recurrences occurred in patients whose plications were performed with the extracorporeal knot-tying device without supplemental intracorporeal instrument tying. Proportion of recurrences in the group that used extracorporeal knot-tying device alone was significantly greater than the recurrences in the group that used intracorporeal instrument tying (alone or supplemental) (P=0.016). The majority (36/41) reported clinical improvement postoperatively and 85% of questionnaire respondents also agreed they would recommend the surgery to others with similar condition. The median LOS and of chest tube duration were 3 days and 2 days, respectively. There were two patients with 30-day readmissions. Three patients developed postoperative pleural effusion necessitating thoracenteses and 8 patients (20%) had postoperative complications. No mortalities were observed.

Conclusions: While our study shows the overall acceptable safety and favorable outcomes in patients undergoing robotic-assisted transthoracic diaphragmatic plications, the incidence of short-term recurrences and its association with the use of extracorporeally knot-tying device alone in diaphragm plication warrant further investigation.

Keywords: Diaphragm; plication; robotic; outcomes

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Introduction

As the principal muscle of ventilation, the diaphragm can become dysfunctional from iatrogenic, traumatic, and idiopathic causes resulting in shortness of breath, exercise intolerance, and difficulty with sleep. Patients who are symptomatic from diaphragmatic dysfunction may benefit from diaphragmatic plication, which has been the mainstay of treatment for almost a century, being first described in 1923 (1). Diaphragmatic plication involves gathering, reefing, and pleating the redundant segments of the hemidiaphragm to achieve tightening and flattening of the structure. Diaphragmatic plications are performed by open and minimally invasive approaches through the chest or abdomen (2). Robotic-assisted techniques have been more recently reported (3-5).

At Vanderbilt University Medical Center (VUMC), diaphragmatic plications are currently performed robotically using a transthoracic approach. There are notable variations of technique used at our institution for securing the suture knots for plications, including using an extracorporeal knot-tying device alone, using intracorporeal knot-tying alone, or a combination of both methods. Here we discuss our experience and the short-term outcomes of patients who underwent transthoracic robotic-assisted diaphragmatic plication over the past three years, with a focus on short-term recurrences and any outcome variations seen with differing knot securing techniques.

Robotic-assisted plication operative technique

Diaphragmatic plications were performed using a robotic -assisted transthoracic approach with the Da Vinci Xi Robotic Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA, USA). Extracorporeal knot crimping devices were used to select cases. After satisfactory induction of anesthesia and insertion of a double lumen endotracheal tube, patients were placed in the lateral decubitus semi-flexed position. The 30-degree camera was inserted along the 5th or 6th intercostal space, inferior to the tip of the scapula and carbon dioxide was infused through the port. Under direct visualization two additional ports were placed anteriorly and posteriorly to the camera port along the same interspace and approximately 8–10 cm each from the camera port. An assistant port was placed posterior to the anterior working site. The robot was docked and instruments were placed. Plication was systematically and serially performed by gathering redundant portions of the diaphragm in an anterolateral to posteromedial fashion using multiple pledgeted, 2-0 non-absorbable horizontal mattress sutures. An extracorporeal device (Ti-KNOT, LSI Solutions, Inc., Victor, NY, USA) was used in the majority of cases to secure knots, and supplemental, reinforcing sutures were sometimes placed with intracorporeal instrument tying. Additional pledgeted sutures were placed until satisfactory flattening of the diaphragm was achieved with removal of remaining redundancy. A chest tube was placed through the anterior port site for pleural drainage. We present the following article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-442/rc).

Methods

Study population and design

A retrospective chart-based review was conducted of all patients who underwent robotic-assisted transthoracic diaphragmatic plication from 2018 to May 2022 at Vanderbilt University Medical Center (VUMC) in Nashville, Tennessee. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Vanderbilt University Medical Center Institutional Review Board (IRB# 210207). Informed consent was taken from all individual participants.

Patient characteristics reviewed included age, sex, body mass index (BMI), smoking status, medical comorbidities, etiology of diaphragmatic dysfunction, and symptomatology (quality and duration of symptoms). Additional information such as operative site, operative time, estimated blood loss (EBL), length of stay (LOS), length of chest tube duration, intraoperative complications, perioperative complications, pre- and postoperative radiologic studies, preoperative pulmonary function tests, subjective postoperative improvement as documented during follow-up visit, and recurrence (characterized by symptoms and imaging) were also recorded. Follow-up was measured as the time between date of surgery and the most recent date seen by

Table 1 Demographics and clinical characteristics of robotic-assisted transthoracic plications

Characteristics	Robotic (n=41)
Gender, n (%)	
Male	29 (73%)
Median age [IQR], years	63 [53, 69]
Median BMI [IQR], kg/m^2	31 [28.8, 34]
Smoking status, n (%)	
Never	26 (63%)
Former	15 (37%)
Etiology of dysfunction, n (%)	
Idiopathic	23 (56%)
Iatrogenic	16 (39%)
Traumatic	1 (2%)
Missing	1 (2%)
Median preoperative symptom duration [IQR], months	10 [6, 24]
Missing, n (%)	4 (10%)
Median FEV_1 [IQR], % predicted	65 [50, 80]
Missing, n (%)	5 (12%)
Median FVC [IQR], % predicted	64 [48, 72]
Missing, n (%)	8 (20%)
Median DLCO [IQR], % predicted	70 [61.5, 83]
Missing, n (%)	13 (32%)
Preoperative sniff testing, n (%)	41 (100%)

BMI, body mass index; IQR, interquartile range; FEV_1, forced expiratory volume in one second, % predicted; FVC, forced vital capacity, % predicted; DLCO, diffusing capacity of the lungs for carbon monoxide, % predicted.

thoracic surgery (either outpatient or inpatient setting). Data were collected and managed using REDCap electronic data capture tools. Eligibility criteria included adults who underwent robotic-assisted transthoracic diaphragmatic plication from 2018 to May 2022 at VUMC. Eligible patients were identified using the electronic medical record.

The primary outcome of our study was short-term recurrence of diaphragm elevation on imaging (chest X-ray or CT) with symptoms before or at the first post-operative follow-up visit as determined by chart review. Secondary outcomes included subjective postoperative improvement of dyspnea as noted during follow-up visit and post-operative patient questionnaire, LOS, complications, 30-day readmission, operative time, EBL, and length of chest tube duration.

Statistical analysis

Patient demographics and clinical characteristics were summarized using descriptive statistics which were calculated as number (percentage) and median [interquartile range (IQR)]. Outcomes were calculated as number (percentage) and median (IQR). Comparison between recurrences was done by test of proportions. All analyses were performed with Stata version 16 (StataCorp, College Station, TX, USA) and P values <0.05 were considered statistically significant.

Patient questionnaire

We created a questionnaire for all patients who underwent robotic-assisted transthoracic diaphragmatic plication during the study period (n=28) (Appendix 1). We excluded two patients with short-term recurrences after robotic-assisted plication who had since undergone repeat plication with thoracotomy. The questionnaire assessed patient reported outcomes after this procedure. We included adapted questions based on the Medical Research Council (MRC) Dyspnea Scale, adapted questions from the RAND 36-Item Short Form Survey developed as part of the Medical Outcomes Study, as well as original questions. We recruited eligible patients by mail. After informed consent was obtained, the questionnaire was administered by telephone or secure web-based link. Patients who endorsed concerning symptoms such as new or worsening shortness of breath during the questionnaire were encouraged to seek care from a primary care provider.

Results

Patient characteristics

From 2018 to 2022, 41 robotic-assisted transthoracic diaphragmatic plications were performed. Majority of patients were male (73%) with a median age of 63 and median BMI of 31. Patient's etiology of diaphragm dysfunction was almost exclusively idiopathic (56%) and iatrogenic (39%) (*Table 1*). The most common medical comorbidities in patients who underwent robotic plication included gastroesophageal reflux disease (16/41),

Table 2 Operative data of robotic-assisted transthoracic plications

Characteristics	Robotic (n=41)
Laterality, n (%)	
Left	15 (37%)
Right	26 (63%)
Median operative time [IQR], minutes	190 [161, 232]
Missing, n (%)	0 (0%)
Median estimated blood loss [IQR], mL	25 [25, 50]
Missing, n (%)	1 (2%)
Intraoperative complications, n (%)	
Yes	0 (0%)
No	41 (100%)

IQR, interquartile range.

hypertension (26/41), and hyperlipidemia (20/27). Almost all patients exhibited respiratory symptoms.

Preoperative pulmonary function tests and imaging

Median percentage of predicted FEV_1 for the cohort was 65%, median percentage predicted FVC was 64%, and median percentage predicted DLCO was 70% with a majority (63%) of patients being never smokers (*Table 1*). All patients underwent preoperative imaging either with chest X-ray or chest computed tomography (CT) which demonstrated abnormal diaphragm elevation. Additionally, all patients underwent preoperative sniff testing which demonstrated suspicion for diaphragmatic dysfunction.

Operative data

Operative data are shown in *Table 2*. The majority of patients underwent right-sided plications. Median operative time was 190 minutes (IQR: 161, 232 minutes). Median EBL was 25 mL (IQR: 25, 50 mL). There were no intraoperative complications noted and no robotic operations required conversion to an open procedure.

Postoperative data

Postoperative data are presented in *Table 3*. Postoperatively, median LOS was 3 days (IQR: 2, 3 days) and median length of chest tube duration was 2 days (IQR: 1, 3 days). Three patients developed postoperative pleural effusions after robotic plications. Of those with pleural effusion, one patient required two hospital readmissions for pneumonia, another developed acute kidney injury (AKI) with altered mental status requiring readmission, and another developed AKI postoperatively which resolved before discharge. Instances of AKI were suspected by clinical team to be from dehydration. One patient developed a pneumothorax after chest tube removal requiring tube replacement, one developed an ileus in addition to urinary retention, one developed atrial fibrillation with rapid ventricular response,

Table 3 Postoperative data and outcomes of robotic-assisted transthoracic plications

Characteristics	Robotic (n=41)
Median length of stay [IQR], days	3 [2, 3]
Median length of chest tube duration [IQR], days	2 [1, 3]
Postoperative pleural effusion, n (%)	
Yes	3 (7%)
No	38 (93%)
Other complication[1], n (%)	
Yes	8 (20%)
No	33 (80%)
Mortality, n (%)	
Yes	0 (0%)
No	41 (100%)
30-day readmission, n (%)	
Yes	2 (5%)
No	38 (95%)
Subjective postoperative clinical improvement, n (%)	
Yes	30 (73%)
No	3 (7%)
Partial	6 (15%)
Missing	2 (5%)
Short-term recurrence, n (%)	
Yes	4 (10%)
No	35 (85%)
Missing	2 (5%)

[1], other perioperative complications included pneumothorax after chest tube removal, hypoxemic respiratory failure, pneumonia, urinary retention, acute kidney injury, arrythmia (atrial fibrillation with rapid ventricular response), and ileus.

two patients had postoperative urinary retention.

Follow-up and recurrences

A total of four (10%) patients experienced short-term recurrent diaphragmatic elevation with symptoms prior to or on their first post-operative follow-up visit after robotic operations. The four recurrences occurred on POD 6, 10, 37, and 38. Recurrence was characterized by symptoms (shortness of breath) and plication breakdown noted on imaging (chest X-ray, CT, or sniff testing). Two of these recurrences occurred after violent sneezing or coughing episodes soon after initial plication, and subsequently underwent redo open plication with thoracotomy. One of the four patients with recurrences underwent repeat robotic transthoracic diaphragmatic plication (*Table 3*).

Extracorporeal knot-tying device use

Of the 41 patients who had underwent robotic plication, 2 patients had short-term recurrences data that were missing and were excluded from the following analysis. Thirty-three patients had plication done with extracorporeal knot-tying device, of those 33 patients, 17 did not have any supplemental knots tied by intracorporeal instrument tying and 15 did have supplemental intracorporeal instrument tying. Data for supplemental knot-tying for two of the 33 patients were excluded due to ambiguous language in the operative report. Eight patients had undergone plication with only using intracorporeal instrument knot-tying with no use of extracorporeal knot-tying device. The four early recurrences were patients all belonging to the group that used extracorporeal knot-tying device only (n=33), representing 23.5% of this subgroup. Proportion of recurrences in group that used extracorporeal knot-tying device only was significantly greater than the recurrences in group that used intracorporeal instrument tying, either alone or supplemental (23.5% *vs.* 0%, P=0.016).

Follow-up questionnaire results

Of 38 patients eligible to complete the questionnaire after robotic plication, 28 agreed to participate, five declined, and five could not be reached. Patient responses to the questionnaire are summarized in *Table 4*. Responses to the select adapted RAND 36-Item Short Form Health Survey questions are presented in *Table 5*. The majority of patients (24/28) endorsed improvement in their breathing after surgery, and the majority (23/28) also endorsed improvement in their activity level after surgery. When asked specifically within the past four weeks how their breathing had changed since surgery, 17 (61%) stated a demonstratable improvement, while 6 (21%) noted no changes since after the surgery. Only 4 (14%) patients noted worsening of breathing, and 1 (4%) noted a return of breathing to baseline prior to surgery. Similar trends were noted when asked about changes in activity level since surgery. When asked whether they would recommend diaphragmatic plication to a friend or relative who was experiencing the same symptoms they had prior to surgery, 24 (85%) patients either strongly agreed or agreed that they would recommend the surgery.

Discussion

Diaphragmatic plication remains the predominate surgical procedure for diaphragmatic dysfunction. While this operation historically has been performed through a thoracotomy, minimally invasive approaches have become more prevalent with the growing global popularity of minimally invasive surgery and its purported benefits to patients and surgeons. At our institution, we perform diaphragmatic plications using a robotic-assisted transthoracic approach. Zwischenberger *et al.* have described the outcomes of three patients who underwent robotic-assisted transabdominal plications while Shumacher *et al.* described the safety and efficacy of robotic-assisted plications in a case series of 14 patients (4,6). Biswas Roy *et al.* published a 3.5-year experience with 22 transabdominal robotic-assisted diaphragmatic plications (7). More recently Bin Asaf *et al.* conducted a retrospective study demonstrating the safety, efficacy, and feasibility of robotic-assisted plication. This study consisted of 18 patients; six of whom underwent plication using a transthoracic approach (3). Lampridis *et al.* also investigated outcomes after robotic-assisted plications compared to open, and found the robotic approach to be safe and effective (8). Furthermore, Gritsuita *et al.* performed a systematic review of all minimally invasive approaches, including thoracoscopic, laparoscopic, robotic-assisted transthoracic and transabdominal methods, and noted that the current clinical data we have do not support the clear preferability of any one approach over the others (9).

Our study illustrates the safety and short-term efficacy of the robotic-assisted transthoracic approach for diaphragmatic plication in 41 patients. There were no

Table 4 Questions and patient responses for questionnaire (n=28)

Question	Response
Think of how your breathing felt after surgery. How did your breathing at that time compare to how it felt before surgery? (n=27)	
Much improved	13 (48%)
Improved	3 (11%)
Slightly improved	8 (30%)
Unchanged	2 (7%)
Slightly worse	0 (0%)
Worse	0 (0%)
Much worse	1 (4%)
Think back to your activity level after surgery. How did your activity level at that time compare to your activity level before surgery? (n=28)	
Much improved	10 (36%)
Improved	7 (25%)
Slightly improved	6 (21%)
Unchanged	4 (14%)
Slightly worse	0 (0%)
Worse	0 (0%)
Much worse	1 (4%)
Within the past four weeks, how has your breathing changed since surgery? (n=28)	
My breathing has improved	17 (61%)
My breathing has not changed since after the surgery	6 (21%)
My breathing has worsened	4 (14%)
My breathing now feels the same as it did before surgery	1 (4%)
Within the past four weeks, how has your activity level changed since surgery? (n=28)	
My activity level has improved	18 (64%)
My activity level has not changed since after the surgery	7 (25%)
My activity level has worsened	0 (0%)
My activity level is now the same as it was before surgery	3 (11%)
How would you describe your current level of breathlessness[1]? (n=28)	
I do not experience any breathlessness except with intense exercise	7 (25%)
I experience breathlessness when walking quickly or up a hill	10 (36%)
I experience breathlessness after walking for fifteen minutes	5 (18%)
I experience breathlessness after walking for a few minutes	6 (21%)
I am too breathless to leave the house for a walk	0 (0%)
How would you rate your pain level now compared to immediately after surgery? (n=28)	
Much better now	20 (71%)
Somewhat better now	5 (18%)
About the same	3 (11%)
Somewhat worse now	0 (0%)
Much worse now	0 (0%)

Table 4 (*continued*)

Table 4 (*continued*)

Question	Response
How strongly do you agree or disagree with the following statement? "I would recommend this surgery to a friend or relative who is experiencing the same symptoms I had before surgery." (n=28)	
Strongly agree	18 (64%)
Agree	6 (21%)
Neither agree nor disagree	2 (7%)
Disagree	1 (4%)
Strongly disagree	1 (4%)

[1], based on Medical Research Council Dyspnea Scale. Used with permission of the Medical Research Council.

Table 5 Adapted RAND 36-item health survey limitations responses—within the past four weeks, has shortness of breath limited any of the following activities for you[2]?

Activity	Response
Intense activities such as running or lifting heavy objects (n=27)	
Yes limited a lot	12 (44%)
Yes limited a little	11 (41%)
No not limited at all	4 (15%)
Moderate activities such as moving a table or pushing a vacuum cleaner (n=28)	
Yes limited a lot	3 (11%)
Yes limited a little	7 (25%)
No not limited at all	18 (64%)
Climbing several flights of stairs (n=27)	
Yes limited a lot	10 (37%)
Yes limited a little	10 (37%)
No not limited at all	7 (26%)
Climbing one flight of stairs (n=28)	
Yes limited a lot	3 (11%)
Yes limited a little	11 (39%)
No not limited at all	14 (50%)
Walking several blocks (n=28)	
Yes limited a lot	9 (32%)
Yes limited a little	8 (29%)
No not limited at all	11 (39%)
Walking one block (n=28)	
Yes limited a lot	1 (3.5%)
Yes limited a little	8 (28.5%)
No not limited at all	19 (68%)

[2], based on 36-Item Health Survey developed at RAND as part of the Medical Outcomes Study.

intraoperative complications, and none required conversion to an open thoracotomy. Furthermore, the majority of patients endorsed subjective postoperative improvement of respiratory symptoms. Among those with short-term recurrence, possible reasons include early vigorous post-operative activity, suture technique, poor tissue compliance, knot securing device failure or devise misuse.

The higher proportion of early recurrences in the group that underwent plication with extracorporeal knot securing device alone versus those in the group that underwent plication with intracorporeal instrument tying, either alone or as supplemental to extracorporeal knot securing device, warrants further investigation. While our test of proportion suggests a significant difference in early recurrence between the two groups, it should not to be used to infer causation. However, it is of great importance to be vigilant in the use of novel medical devices and the new application of known devices. We need to understand the limitations, possible safety concerns, as well as the potential benefits. For the surgeons in our thoracic surgery group, concerns surrounding these early recurrences with extracorporeal knot securing devices have led to a practice shift from using extracorporeal knot securing devices alone to now supplementing with intracorporeal instrument tied knots. There has also been an increased emphasis on education and close supervision of proper technique in the use of extracorporeal knot-tying devices in the operating room for the bedside assistants. Almost exclusively in robotic diaphragmatic plication surgery, the extracorporeal knot-tying devices are used by the bedside assistants under the direction of the primary surgeon who is at the robot console. The bedside assistant role is most typically a surgeon in-training or a non-physician surgical assistant, both of whom have varying degrees of experience with the surgery and the extracorporeal knot-tying device.

Looking at secondary outcomes overall, there does not appear to be significant areas of concern in the post-operative period. The median LOS was 3 days followed by 2 days for median length of chest tube duration. While there were no associated mortality or intraoperative complications, there were post-operative complications, at a rate of 20%, with the most common complication being AKI, followed by urinary retention. Both conditions were improving or resolved by the time of discharge for patients. Of note, pleural effusions requiring thoracentesis after discharge did occur in 3 patients.

On follow-up using our questionnaire, 82% of patients endorsed continued clinical improvement with breathing and 89% endorsed continued activity level improvement in the past month, and no one endorsed worse pain. While eight patients stated their dyspnea and/or activity level had either worsened or returned to preoperative levels, we cannot conclude this is related to the plication given the limited questioning and lack of imaging. The majority of patients (85%) noted that they would recommend plication to a friend or relative experiencing similar symptoms, demonstrating an overall satisfaction with the procedure.

Our study has several limitations including a small sample size from one large academic medical center which could affect the generalizability of our results. Additionally, there was as a lack of postoperative pulmonary function testing. Patients generally followed-up with a routine postoperative visit within four to eight weeks of discharge. If the patient was recovering uneventfully and postoperative imaging (chest X-ray) was satisfactory, further follow-up was continued as-needed with their regular healthcare provider and not the surgeon. Furthermore, given the learning curve associated with robotic surgery, the inclusion of early experiences with robotic-assisted plications could bias our results for variables such as operative time and early recurrence. Limitations of our follow-up questionnaire include the small sample size, lack of corresponding imaging and pulmonary function data, lack of preoperative questionnaire data, as well as the potential for recall bias.

Conclusions

In conclusion, diaphragmatic plication can be performed safely using a robotic transthoracic approach. However, our experience does raise some questions regarding the possible association between extracorporeal knot-tying device and early recurrences, especially in setting when no supplemental intracorporeal instrument tying is performed. While further work is needed to assess long-term outcomes and efficacy, our study demonstrates the overall safety and short-term efficacy of robotic-assisted transthoracic diaphragmatic plications.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-442/rc

Data Sharing Statement: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-442/dss

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Vanderbilt University Medical Center Institutional Review Board (IRB# 210207). Informed consent was taken from all individual participants.

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Supplementary

Short-Term Outcomes of Robotic Assisted versus Open Transthoracic Diaphragmatic Plication Supplement- Patient Questionnaire

1. Think of how your breathing felt after surgery. How did your breathing at that time compare to how it felt before surgery?
   - Much improved
   - Improved
   - Slightly improved
   - Unchanged
   - Slightly worse
   - Worse
   - Much worse

2. Think back to your activity level after surgery. How did your activity level at that time compare to your activity level before surgery?
   - Much improved
   - Improved
   - Slightly improved
   - Unchanged
   - Slightly worse
   - Worse
   - Much worse

3. Within the past four weeks, how has your breathing changed since surgery?
   - My breathing has improved
   - My breathing has not changed since after the surgery
   - My breathing has worsened
   - My breathing now feels the same as it did before surgery

4. Within the past four weeks, how has your activity level changed since surgery?
   - My activity level has improved
   - My activity level has not changed since after the surgery
   - My activity level has worsened
   - My activity level is now the same as it was before surgery

5. How would you describe your current level of breathlessness?[3]
   - I do not experience any breathlessness except with intense exercise
   - I experience breathlessness when walking quickly or up a hill
   - I experience breathlessness after walking for fifteen minutes
   - I experience breathlessness after walking for a few minutes
   - I am too breathless to leave the house for a walk

6. Within the past four weeks, has shortness of breath limited any of the following activities for you?[4]
   Intense activities such as running or lifting heavy objects
   - Yes, limited a lot
   - Yes, limited a little
   - No, not limited at all

[3] Based on Medical Research Council Dyspnea Scale. Used with permission of the Medical Research Council.

[4] Based on 36-Item Health Survey developed at RAND as part of the Medical Outcomes Study

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Moderate activities such as moving a table or pushing a vacuum cleaner
- Yes, limited a lot
- Yes, limited a little
- No, not limited at all

Climbing several flights of stairs
- Yes, limited a lot
- Yes, limited a little
- No, not limited at all

Climbing one flight of stairs
- Yes, limited a lot
- Yes, limited a little
- No, not limited at all

Walking several blocks
- Yes, limited a lot
- Yes, limited a little
- No, not limited at all

Walking one block
- Yes, limited a lot
- Yes, limited a little
- No, not limited at all

7. How would you rate your pain level now compared to immediately after surgery?
   - Much better now
   - Somewhat better now
   - About the same
   - Somewhat worse now
   - Much worse now

8. How strongly do you agree or disagree with the following statement? "I would recommend this surgery to a friend or relative who is experiencing the same symptoms I had before surgery."
   - Strongly agree
   - Agree
   - Neither agree nor disagree
   - Disagree
   - Strongly disagree

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