

# Trendelenburg-Related Brachial Plexus Injuries in Gynecologic Surgery

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## ABSTRACT

**Introduction:** Brachial plexus injuries are infrequent but preventable complications of laparoscopic and robot-assisted gynecologic surgery.

**Case Description:** A 32-year-old woman with a history of uterine leiomyomata, menorrhagia, and chronic pelvic pain underwent a robot-assisted laparoscopic myomectomy. Preoperative radiologic imaging showed an enlarged uterus with a large, 8.6 × 7.2 × 9.2-cm, intramural left uterine body leiomyoma. Bleeding and difficulty visualizing the surgical dissection planes complicated intraoperative enucleation of the leiomyoma. This resulted in a total surgical time of 400 minutes, during which the patient spent approximately 320 minutes in the steep Trendelenburg position. On postoperative day 1, the patient reported weakness and tingling in her left arm and fingers and was found to have an acute left brachial plexus injury. After a course of oral corticosteroids and outpatient physical therapy, the patient reported no residual neurologic deficits during her subsequent postoperative visits.

**Discussion:** As gynecologists cope with the learning curve associated with laparoscopic and robot-assisted laparoscopic surgery, longer operating times will be encountered, with patients spending a significant amount of intraoperative time in the Trendelenburg position. The resulting risks of intraoperative nerve injuries, particularly brachial plexus injuries, may therefore be higher than expected. Because these injuries can cause significant postoperative morbidity, and sometimes even have medicolegal implications, every effort should be made to prevent them. To achieve this, we emphasize the combined efforts of the nursing, surgical, and anesthesia teams to ensure proper patient positioning in the operating room.

**Key Words:** Brachial plexus injury, Laparoscopy, Robotics, Patient positioning, Trendelenburg.

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## INTRODUCTION

Gynecologic surgery has undergone a dramatic transformation in the past decade because of refinement of laparoscopic techniques. Although the laparoscopic approach offers smaller incisions, decreased blood loss, and shorter hospitalizations compared with traditional laparotomy,

nerve injuries due to patient positioning may occasionally complicate laparoscopic surgery.<sup>1-3</sup> Brachial plexus injuries (BPIs) are uncommon nerve injuries that may occur during laparoscopic and robot-assisted surgery.<sup>1,2</sup> We present the case of a patient in whom a BPI developed after a lengthy robot-assisted laparoscopic myomectomy. In addition to reviewing the risks that predispose patients

to this complication, we provide tips and techniques to help circumvent this infrequent complication.

## CASE

A 32-year-old white woman, gravida 0, with a history of uterine leiomyomata, menorrhagia, and chronic pelvic pain presented for counseling regarding definitive surgical therapy. Various medical modalities had previously failed, including tranexamic acid and a levonorgestrel intrauterine device. The patient's medical and surgical history was unremarkable. Preoperative transvaginal and transabdominal ultrasonography showed an enlarged uterus measuring  $11.4 \times 9.9 \times 9.9$  cm with an intramural left uterine body leiomyoma measuring  $8.6 \times 7.2 \times 9.2$  cm. Minimally invasive surgical options were discussed with the patient, and with the aim of fertility preservation, the patient opted for a robot-assisted laparoscopic myomectomy.

The patient was placed in a dorsal lithotomy position for the procedure. Her arms and hands were padded with 2-inch-thick egg crate foam cushions (Universal Medical, Norwood, Massachusetts), and using the sheet under her back, we tucked both her arms straight to her sides with her palms open and facing her thighs. The patient lay directly on top of a 4-inch-thick egg crate foam mattress (BioClinic; Joerns Medical, Charlotte, North Carolina), and the patient's back sheet was tucked under this foam mattress. In anticipation of steep Trendelenburg positioning during surgery, we attached padded shoulder braces (Allen Medical Systems, Acton, Massachusetts) to the operating table. The patient's position on the operating table was confirmed at a  $0^\circ$  and  $30^\circ$  tilt by the surgical, anesthesia, and scrub teams.

After placement of a 12-mm supraumbilical port, two 8-mm ports, and an additional 10-mm accessory port, the standard da Vinci surgical system (Intuitive Surgical, Sunnyvale, California) was straight docked between the patient's legs. The leiomyoma was identified intraoperatively, and dilute vasopressin solution was injected around the leiomyoma site with a 22-gauge spinal needle until blanching of the myometrium was noted. A longitudinal hysterotomy was created, the leiomyoma capsule was identified, and the leiomyoma was enucleated with an EndoWrist tenaculum (Intuitive Surgical) and a monopolar cutting device. Intraoperative enucleation of the leiomyoma was made challenging by the presence of adenomyosis, which made visualization of the surgical planes difficult. This step also resulted in greater-than-usual intraoperative bleeding, primarily

due to traction applied to the leiomyoma. The hysterotomy was closed in 3 layers with a No. 2-0 V-Loc suture (Covidien, Mansfield, Massachusetts), and the leiomyoma was extracted from the abdomen by use of a morcellator. The estimated blood loss was 300 mL, and the total surgical time was 400 minutes; the patient spent approximately 320 minutes in the steep Trendelenburg position.

On postoperative day 1, the patient reported weakness and tingling in her left arm and fingers. A general physical examination showed erythema and tenderness of the left shoulder. A detailed neurologic examination was significant for 3/5 motor strength of the left biceps and wrist extensors, as well as +1 biceps and triceps reflexes. Touch and temperature sensation remained normal throughout the left arm. Magnetic resonance imaging of the cervical spine showed negative findings for cervical vertebral fracture, subluxation, and cervical canal stenosis. After a detailed neurologic evaluation, we suspected that the patient had an acute BPI.

The patient was prescribed 300 mg of oral gabapentin 3 times a day and a course of oral prednisone beginning at 60 mg, with a 10-mg taper on successive days. She also underwent physical therapy for her left arm. Neurologic examination on postoperative day 2 showed 4/5 motor strength of the left arm, with normal biceps and triceps reflexes. She was subsequently discharged on postoperative day 2; continued her oral medications, as well as outpatient physical therapy; and reported no residual neurologic deficits during her postoperative visits 1, 3, and 6 weeks later.

## DISCUSSION

Although BPIs are rare complications, they have been well described in a variety of surgical settings.<sup>4-6</sup> It is essential to distinguish between BPIs that occur during median sternotomy or spinal surgery and those that occur as a result of patient positioning during surgery.<sup>4-6</sup> BPIs resulting from laparoscopic or robot-assisted surgery requiring prolonged periods of Trendelenburg positioning remain uncommon, complicating only 0.16% of all surgical procedures.<sup>2</sup> Yet, these injuries have significant postoperative morbidity and medicolegal implications.<sup>7-10</sup> We searched Medline using PubMed for all English-language articles published between 1980 and 2012 with search terms including "brachial plexus injury," "brachial plexus neuropathy," "brachial plexopathy," and "laparoscopy." Although cases associated with postoperative BPIs after laparoscopic general, urologic,

and gynecologic surgery have previously been reported, we found no cases of BPI after robot-assisted gynecologic surgery. The findings of our literature search are summarized in **Table 1**.<sup>6,11–25</sup>

The brachial plexus, comprising nerves C5 to T1, runs beneath the clavicle and enters the arm medial to the humeral head.<sup>1,3</sup> Normally, neighboring bones protect the brachial plexus from injury; however, the proximity of the brachial plexus to these mobile neighboring bony structures leaves it vulnerable to injury related to malpositioning.<sup>1,3</sup> BPIs may occur when the brachial plexus is stretched or compressed.<sup>1,3</sup> Stretch injuries usually occur when shoulder braces are placed too laterally, especially when the arm is abducted.<sup>1,3</sup> Two opposing forces stretch the nerves of the brachial plexus: an upward force on the shoulder by the shoulder brace and the downward force of gravity on the patient.<sup>1,3</sup> In contrast, compression injury occurs when shoulder braces are placed too close to the neck with the arm hyperabducted, thereby compressing the brachial plexus against the first rib.<sup>3,7</sup>

Injuries to peripheral nerves occur because of a combination of stretch and compression that ultimately causes local ischemia to these nerves.<sup>7</sup> Several risk factors have been implicated in the development of intraoperative BPIs.<sup>1–3,7,8</sup> The Trendelenburg position is often used during laparoscopic gynecologic surgery to facilitate intra-abdominal exposure; however, shoulder braces used in conjunction with the Trendelenburg position predispose patients to BPIs. In this scenario the force of the shoulder braces on the clavicle and scapula opposes the force of gravity on the humerus, thereby stretching the brachial plexus and leading to a nerve injury.<sup>1–3,7,8</sup> This risk is particularly exaggerated when the arm is hyperabducted ( $>90^\circ$ ), the head is laterally flexed to the opposite side, or the abducted arm is sagging.<sup>25</sup> With increased operating times, patients remain under general anesthesia longer; this increases the risk of a BPI by increasing joint mobility (particularly when muscle relaxants are used) because the neighboring bony structure is more likely to compress or impinge on the brachial plexus.<sup>3</sup> Patients with extreme body mass index (BMI) values, cervical spine abnormalities, congenital anomalies such as a cervical rib, or pre-existing diabetes or other chronic vascular diseases are also more prone to the development of BPIs.<sup>1,3,7</sup> Moreover, hypothermia, hypovolemia, and hypotension during surgery may contribute to the risk of BPIs developing.<sup>1</sup> Finally, electrolyte imbalances, vitamin B<sub>12</sub> deficiency, alcoholism, and smoking may predispose patients to the development of neuropathies.<sup>1</sup>

Our search for cases of laparoscopic gynecologic surgery complicated by BPIs showed 8 published reports, which highlight several risk factors (**Table 1**). The Trendelenburg position was used in all cases, with a mean tilt angle of  $28.5^\circ$  (range,  $20^\circ$ – $38^\circ$ ). Shoulder braces, however, were used in only 6 cases. Five cases reported patient positioning with 1 arm abducted; in 2 additional cases, patients had both arms abducted. The mean operating time was 189.1 minutes (range, 60–360 minutes), and the mean BMI of patients was  $32.2 \text{ kg/m}^2$  (range,  $19.6$ – $70 \text{ kg/m}^2$ ). Although half these patients were either obese or morbidly obese, the remaining half were at the lower end of normal BMI values.

Consistent with the aforementioned risk factors, our case involved a patient with a low-normal BMI,<sup>19</sup> who spent approximately 320 minutes in the steep Trendelenburg position. Although the patient's arms were not abducted, shoulder braces were used in this case. We hypothesize that a stretch injury of the brachial plexus developed in our patient because of the combination of shoulder braces, Trendelenburg positioning, and prolonged operating time.

A history of a long laparoscopic or robot-assisted surgery, with reports of pain, numbness, and tingling along one or both arms postoperatively, should always alert a gynecologist to the possibility of a BPI.<sup>1</sup> Although BPIs can be diagnosed by a combination of clinical history and detailed neurologic findings, magnetic resonance imaging can be used as an adjunct when cervical radiculopathy is suspected.<sup>1</sup> Although most BPIs are transient and resolve spontaneously, depending on the extent of ischemia to the brachial plexus, BPIs can lead to short- or long-term dysfunction, including tingling, numbness, pain, and loss of function in the upper extremities.<sup>1,3,8</sup> The mainstay of treatment is physical therapy of the affected side, as well as oral nonsteroidal anti-inflammatory drugs, or anti-epileptic agents such as gabapentin or topiramate if the patient has neuropathic pain.<sup>1</sup> Treatment efficacy is monitored clinically; however, nerve conduction studies and electromyography may be required to evaluate the extent of injury if neurologic symptoms persist for  $>4$  weeks.<sup>1</sup> The diagnosis of BPI in our patient was achieved clinically, and in conjunction with physical therapy and oral analgesics, the patient showed resolution of symptoms within 4 weeks of her initial surgery.

A consistent and standardized approach to patient positioning is integral to any surgical procedure because the patient is subject to intraoperative complications as soon as he or she is placed on the operating table.<sup>8</sup> Prevention

**Table 1**  
Laparoscopic Gynecologic, Urologic, and General Surgical Cases Complicated by Postoperative BPIs Reported in Medical Literature Between 1980 and 2012

| Brief Clinical Case   | BMI (kg/m <sup>2</sup> ) | Laparoscopic Surgery Type                  | Patient Positioning  | Trendelenburg (°)                        | Operating Time (min) | Specific Neurologic Deficit                       | Treatment/Outcome   | Reference                           |
|---|--------------------------|--|--|--|----------------------|---|---|-------------------------------------|
| Gynecologic Surgery<br>Case series of 67 patients, with 2 cases complicated by unilateral BPI | Not reported             | Salpingo-ovariolysis and salpingostomies   | Steep Trendelenburg  | 38                                       | 85 (mean)            | Not reported                                      | Complete spontaneous recovery   | Reich <sup>11</sup>                 |
| Woman aged 28 y with pelvic pain and infertility  | 19.6                     | Not reported                               | Left arm tucked, right arm at 90°, shoulder braces used                    | 20                                       | 225                  | Right arm and middle finger numbness and weakness | Not reported/gradual resolution with no residual deficits   | Romanowski et al <sup>2</sup>       |
| Woman aged 34 y with hypermenorrhea and 25 × 15 × 15-cm pelvic mass                           | 30.6                     | Not reported                               | Left arm tucked, right arm at 90°, shoulder braces used                    | 20, 30                                   | 180, 200             | Right arm numbness                                | Not reported/gradual resolution with no residual deficits   | Romanowski et al <sup>2</sup>       |
| Woman aged 67 y with pelvic pain  | 21.6                     | Not reported                               | Left arm tucked, right arm at 90°, shoulder braces used                    | 30                                       | 60                   | Right shoulder pain and right arm numbness        | Not reported/gradual resolution with no residual deficits   | Romanowski et al <sup>2</sup>       |
| Woman aged 42 y with hypermenorrhea and adnexal mass  | 40.7                     | Not reported                               | Left arm tucked, right arm at 90°, shoulder braces used                    | 30                                       | 220                  | Bilateral arm numbness and weakness               | Not reported/gradual resolution with no residual deficits   | Romanowski et al <sup>2</sup>       |
| Woman aged 28 y with pelvic pain, infertility, and 10 × 10 × 8-cm pelvic mass                 | 20.9                     | Not reported                               | Left arm tucked, right arm at 90°, shoulder braces used                    | 30                                       | 300                  | Right arm numbness and weakness                   | Not reported/gradual resolution with no residual deficits   | Romanowski et al <sup>2</sup>       |
| Woman aged 30 y with worsening abdominal pain and 8-cm right ovarian cyst                     | 70 kg                    | Pelvic adhesiolysis and right oophorectomy | Both arms abducted to 90°, shoulder braces used                            | 30                                       | 72                   | Left arm pain and weakness                        | Physiotherapy with peripheral neurotension techniques and electric nerve stimulation/5 mo of therapy, no maximum rotation of muscle and slow movement | Lachman et al <sup>12</sup>         |
| Woman aged 69 y with known ovarian tumor  | 22.0                     | Not reported                               | Both arms abducted with hard pillow at T10-T11 level                       | Yes, but degree not reported             | 360                  | Bilateral arm numbness and weakness               | Physiotherapy/complete spontaneous recovery   | Motamed et al <sup>14</sup>         |
| Woman aged 30 y with uterine leiomyomata, pelvic pain, and infertility                        | 19                       | Robot-assisted myomectomy                  | Both arms abducted tucked, shoulder braces used                            | 30                                       | 440                  | Left arm numbness and weakness                    | Oral prednisone taper, physiotherapy/complete spontaneous recovery within 1 wk  | Current case                        |
| Urologic Surgery<br>Case series of 11 patients, with 1 case complicated by BPI                | Not reported             | Nephrectomy                                | Arm not abducted more than 90°, body straps used                           | Yes, but degree not reported             | 366 (mean)           | Not reported                                      | Not reported/mildly improved 12 mo later  | Dunn et al <sup>15</sup>            |
| Man aged 42 y with mild hypertension and renal insufficiency                                  | 24.6                     | Radical nephrectomy                        | Right lateral decubitus, left arm hyperabducted at 120° under left scapula | Leaned backward 60° with supporting roll | 420                  | Left upper arm weakness                           | Physiotherapy/hyperesthesia in affected arm at 1 mo of follow-up  | Ngamprasertwong et al <sup>16</sup> |

Table 1 continued on next page.

**Table 1. (continued)**  
Laparoscopic Gynecologic, Urologic, and General Surgical Cases Complicated by Postoperative BPIs Reported in Medical Literature Between 1980 and 2012

| Brief Clinical Case  | BMI (kg/m <sup>2</sup> ) | Laparoscopic Surgery Type             | Patient Positioning  | Trendelenburg (°)            | Operating Time (min) | Specific Neurologic Deficit                                | Treatment/Outcome  | Reference                     |
|--|--------------------------|---------------------------------------|--|------------------------------|----------------------|--|--|-------------------------------|
| Case series of 10 patients, with 1 case complicated by left brachial plexus paralysis          | Not reported             | Live donor nephrectomy                | 60° oblique position with left side upmost                         | Not reported                 | 245 (mean)           | Transient left brachial plexus paralysis                   | Physiotherapy/complete spontaneous recovery  | Wu et al <sup>17</sup>        |
| Case series of 25 patients, with 3 cases complicated by transient brachial plexus neuropathies | 25.6 (mean)              | Donor nephrectomy                     | 60° oblique position with left side upmost                         | Not reported                 | 274 (mean)           | Transient left brachial plexus neuropathy                  | Not reported/complete recovery within 1 wk   | Liu et al <sup>18</sup>       |
| Man aged 65 y with hypertension, hyperlipidemia, and enlarged prostate                         | 27.1                     | Robot-assisted radical prostatectomy  | Lithotomy with both arms tucked by side, shoulder braces used      | 45                           | 255                  | Right arm weakness   | Not reported/complete spontaneous recovery on postoperative day 5                                  | Phong and Kohl <sup>19</sup>  |
| General surgery  |                          |                                       |  |                              |                      |  |  |                               |
| Case series of 16 patients, with 1 case complicated by transient brachial plexus neuropathies  | Not reported             | Colectomy with ileorectal anastomosis | Modified lithotomy, shoulder braces used                           | Yes, but degree not reported | 232 (mean)           | Not reported   | Physiotherapy/complete spontaneous recovery  | Milsom et al <sup>20</sup>    |
| Man aged 39 y with diverticular disease  | 82 kg                    | Sigmoid colectomy                     | Lloyd-Davis position, both arms tucked                             | 20                           | 175                  | Bilateral arm numbness and weakness                        | Physiotherapy/complete recovery after 6 mo; still has pain   | Chin and Poole <sup>21</sup>  |
| Man aged 55 y with diverticular disease  | 28                       | Anterior resection                    | Lloyd-Davis position, 15° right lateral tilt, shoulder braces used | 30–40, 20                    | 90, 60               | Right arm numbness   | Physiotherapy/complete spontaneous recovery in 5 d   | Craig <sup>22</sup>           |
| Case series of 43 patients, with 1 case complicated by brachial plexus neuralgia               | 24.5 (mean)              | Internal enteric fistula repairs      | Not reported   | Not reported                 | 155 (mean)           | Not reported   | Physiotherapy/complete spontaneous recovery  | Pokala et al <sup>23</sup>    |
| Man aged 39 y with morbid obesity  | 45.5                     | Roux-en-Y gastric bypass              | Both arms abducted not more than 60°                               | 40                           | 330                  | Bilateral arm numbness and weakness; right Horner syndrome | Physiotherapy/complete recovery after 9 mo   | Brunette et al <sup>6</sup>   |
| Case series of 54 patients, with 2 cases complicated by brachial plexus palsy                  | Not reported             | Rectopexy                             | Not reported   | Yes, but degree not reported | 157 (mean)           | Not reported   | None/complete recovery within few days in 1 patient; partial recovery at 2 years in second patient | Auguste et al <sup>24</sup>   |
| Man aged 39 y with recurrent diverticular disease  | 26.3                     | Sigmoid colectomy                     | Both arms abducted to 60°, shoulder braces used                    | 20                           | 170                  | Bilateral arm weakness                                     | Physiotherapy and topiramate/continuing bilateral shoulder and arm pain >3.5 y later               | Kent and Cheney <sup>25</sup> |

of intraoperative BPIs, particularly during laparoscopic and robot-assisted gynecologic surgery, should take into account the anatomy of the brachial plexus, as well as the aforementioned risk factors that predispose patients to the development of BPIs.<sup>1,8</sup> First, the time spent in the Trendelenburg position, as well as the tilt angle, should be minimized without compromising surgical exposure.<sup>1</sup> A recent study by Ghomi et al<sup>13</sup> has questioned the utility of steep Trendelenburg positioning in gynecologic surgery, particularly robot-assisted laparoscopic surgery. They used a mean tilt angle of 16.4° and concluded that robot-assisted laparoscopic surgery could be performed effectively without using steep Trendelenburg positioning. They emphasized that a surgeon's skill and experience should dictate the degree of Trendelenburg positioning to achieve surgical exposure, rather than routinely placing all patients in the steep Trendelenburg position. Minimizing the tilt angle would thereby decrease any intraoperative or postoperative respiratory, circulatory, or neurologic complications. Second, use of shoulder braces or restraints should be limited; instead, alternatives such as cross-chest straps, beanbags, gel pads, or egg crate foam mattresses should be used to prevent the patient from slipping cephalad during surgery.<sup>1,3,8</sup> If shoulder braces must be used, proper placement over the acromioclavicular joint should be ensured.<sup>3</sup> Third, use of arm boards should be prohibited; the patient's arms should instead be tucked to the side with the hands facing his or her thighs.<sup>1</sup> Finally, members of the surgical team and operating room staff should remain cognizant of the operating time so that adjustments to the patient's intraoperative position can be made when necessary.<sup>1</sup>

Minimally invasive surgical options, particularly laparoscopic and now robot-assisted laparoscopic surgery, have revolutionized the surgical management of different gynecologic conditions. These surgical procedures often require longer operating times because of instrument preparation and setup as well as physician technique; that is, they have a learning curve.<sup>8</sup> Because patients inevitably spend longer times in the Trendelenburg position during gynecologic surgeries, intraoperative nerve injuries related to patient positioning are bound to occur. Although nerve injuries such as BPIs are rare complications of surgery, these injuries may be debilitating and can pose medicolegal implications as well.<sup>1,3,8</sup>

Patient positioning in the operating room should be a team effort that optimizes surgical efficacy without compromising patient safety.<sup>3,8</sup> To achieve this, members of the nursing, surgical, and anesthesia teams must

make a thorough preoperative assessment to identify risk factors that make the patient susceptible to injury. During long laparoscopic and robot-assisted gynecologic surgeries, the anesthesiologist should make repeated intraoperative assessments to recognize and address any causes of positioning-related BPIs. Because the patient's arms remain outside the surgeon's field of vision, the anesthesiologist should take precautions regarding the placement and stability of the patient's arms.<sup>12</sup> Although nerve injuries due to patient positioning may still occur despite adequate preventive measures, understanding proper neuroanatomic relationships, mechanisms of injury, and risk factors that make patients prone to such injuries can help minimize these surgical complications.<sup>1,3,8</sup>

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