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Anatomically-Guided Botulism Toxin Injections for Enhanced Abdominal Muscle Relaxation Prior to Massive Inguinal Hernia Repair: A Case Report

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Background: The use of botulism toxin A (BTA) to augment abdominal muscle relaxation for surgical hernia repair is well described. However, guidance on the anatomic considerations to facilitate safe and ideal abdominal wall BTA injection patterns is limited.

Case Report: A 37-year-old man presented with a 26-cm inguinal hernia and abdominal content loss of domain. Due to high risk of incomplete abdominal closure, abdominal compartment syndrome, and prolonged postoperative ventilatory support, a multidisciplinary approach to surgical closure was sought with therapeutic input from a comprehensive pain clinic. The patient was injected with BTA into the bilateral internal and external oblique muscles 2 weeks preoperatively. The injection pattern design employed anatomic considerations for points of maximum abdominal wall tension and anticipated BTA spread. Subsequent muscle paralysis facilitated successful surgery with minimal tension upon closure.

Conclusion: This case supports the safe and effective use of BTA for enhanced abdominal wall relaxation prior to major inguinal hernia repair. When considering BTA therapy for abdominal muscle relaxation augmentation, the choice of injection pattern should include points of maximum tension and injections of close-enough proximity for BTA spread and overlap to maximize procedure benefit, regardless of the location or type of abdominal wall hernia repair.

Key words: Botulism toxin, abdominal muscle relaxation, hernia repair, inguinal hernia, regional anesthesia, case report

BACKGROUND

A unique situation in which a regional anesthesiologist may facilitate the success of a surgical procedure beyond typical pain control is the use of botulism toxin A (BTA) injections for major abdominal hernia reconstruction (1). When injected into tissue, BTA binds with high affinity to glycoprotein structures located on the cholinergic nerve terminal, temporarily blocking the cholinergic synapse. The effect of motor paralysis can be evident as soon as 2 to 3 days following injection, and commonly peaks around 2 to 3 weeks following injection, lasting for up to 6 months total (1,2). Although use of BTA for abdominal wall relaxation is not FDA-approved (off-label), as delayed primary fascial closure is associated with significant rates of morbidity including wound infection and abscess or fistula formation (3), uti-

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lizing techniques like BTA injections to achieve primary fascial closure on first attempt may promote improved surgical outcomes. This technique was first described in 2009 in a prospective case series of 12 patients with a 100% primary closure rate with minimal abdominal wall tension (1). The technique has been further described in multiple reports and case series with greater than 80% success of primary closure without new or recurrent hernias (4-8). A recent meta-analysis supports overall effectiveness at achieving the desired clinical endpoint of abdominal wall muscle relaxation and elongation (9).

In this case report, we present a patient with a 26-cm incarcerated inguinal hernia with abdominal content loss of domain who underwent injection of BTA prior to planned massive inguinal hernia repair. This case highlights specific anatomic considerations for ideal BTA site injection that can be adapted for other hernia sites. Furthermore, it reinforces multidisciplinary efforts between anesthesiologists and surgeons for procedural planning and success.

CASE

A 37-year-old man (BMI 35.6 kg/m^2) with a 22 x 26-cm incarcerated inguinal hernia with abdominal content loss of domain presented to the interventional pain and procedure clinic for evaluation of BTA injections to promote abdominal wall closure. The patient was referred by general surgery given concerns for incomplete abdominal closure and abdominal compartment syndrome necessitating prolonged postoperative ventilator support.

The BTA injection was performed in the outpatient pain clinic. After placing the patient supine and sterile prep of the bilateral flanks, a high-frequency linear ultrasound transducer (Phillips™ Sonosite, Amsterdam, Netherlands) was applied to the abdomen, identifying the 3 muscular layers of the external oblique, internal oblique, and transversus abdominis muscle. Five points for each side were identified, 2 over the midaxillary line, between the costal border and the superior iliac crest, and 3 over the external oblique muscle, replicating prior injection techniques (1). At all points, the 3 muscle layers were visible. Notably, no abdominal bowel could be seen, consistent with the patient's loss of domain pathology. At the entry site, 1 mL of 2% lidocaine was used to anesthetize the skin and subcutaneous tissue. Using an in-plane approach, a 22-gauge, 6-inch needle (Pajunk SonoPlex, Geisingen, Germany) was advanced under real time ultrasound imaging (Fig. 1). The tip of the needle was placed into the body of the internal oblique muscle. After negative aspiration, 20 U of onabotulinum toxin A BTA (Botox™; Allergan Pharmaceuticals, Dublin, Ireland) was injected. The needle was withdrawn into the body of the external oblique and after negative aspiration, another 20 U BTA was injected. The needle was repositioned after rotating the ultrasound probe 45 degrees and the procedure was repeated. This was repeated 4 additional times for a total of 200 U BTA injected into the left flank. The same procedure was repeated on the patient's contralateral side (Fig. 1) for a total 400-U BTA dose.

Two weeks following the BTA injections, the patient proceeded with definitive surgical repair of the massive incarcerated inguinal hernia (Fig. 2). During induction of general anesthesia and before abdominal closure, peak airway pressures remained less than 20 cm H_2O (with application of positive end-expiratory pressure of 5 cm H_2O, driving pressure 15 cm H_2O) to achieve tidal volumes of 6 to 8 mL/kg (ideal body weight). Following extensive surgical repair with mesh, minimal tension closure was achieved, and the patient's abdomen was primarily closed (Fig. 3). Following abdominal closure, peak airway pressures remained less than 30 cm H_2O.

Postoperatively, the patient was transferred to the intensive care unit intubated and sedated for prophylactic monitoring of abdominal compartment syndrome given the significant abdominal loss of domain. Although the patient was initially oliguric, this recovered with supportive care, without the need for renal replacement therapy. The patient was extubated to nasal cannula oxygen on postoperative day one. The postoperative course was complicated by prolonged ileus; however, there was no recurrence of the hernia or need for surgical reexploration. Per local institutional guidelines, institutional review board approval was not required for the generation of this report; however, informed consent via the appropriate Health Insurance Portability and Accountability Act (HIPAA) and institutional authorization was obtained from the patient for generation of this report.

DISCUSSION

BTA injections have been described with increasing frequency in the surgical literature for aiding minimal tension closure in large, complex hernias (1,4-6,10,11). In this case, we performed bilateral flank injections of BTA to facilitate operative repair of a massive incarcerated inguinal hernia, ultimately avoiding incomplete

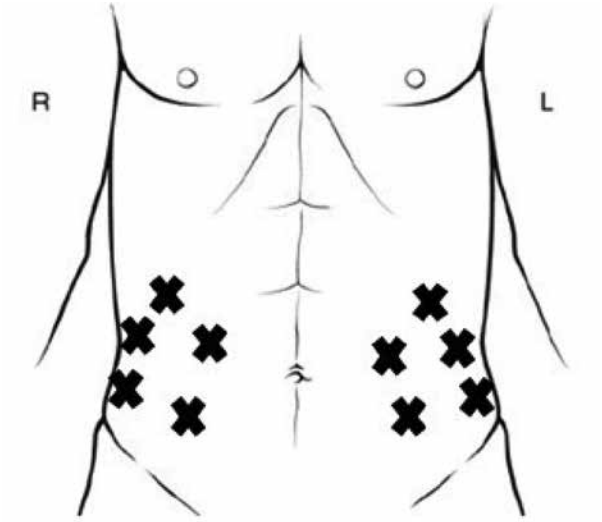

Fig. 1. Anatomic locations of injection sites. Five points for each side were identified; 2 over the midaxillary line between the costal border and the superior iliac crest, and 3 over the oblique musculature. X denotes injection site.

abdominal closure, abdominal compartment syndrome, and prolonged postoperative ventilatory support.

Success of the use of this technique, regardless of abdominal wall hernia location (i.e., ventral, inguinal, etc.) requires application of anatomic principles and an understanding of points of maximal abdominal wall tension. Tension is the force of contact exerted by a rope, cable, or chain. In the abdominal wall, tension is calculated using La Place's law, in which tension is equal to diameter times pressure divided by 4 times the wall thickness (12). The "cable" in the abdominal wall would be the linea semilunaris. It is the union of tendons from the external oblique, internal oblique, and transversus abdominis. The diameter is the greatest in the horizontal axis and the wall thickness of the abdominal musculature is the greatest in the lateral aspects. Based on these physical principles, we estimate the greatest degree of tension will be generated in Zone III and lateral Zone II of the abdominal wall. Zone II is the lower abdominal wall below the arcuate line. Zone III is the lateral abdominal wall lateral to the linea semilunaris. Our hypothesis is supported by a study that measured abdominal wall tension with a novel device (13).

Based on these anatomical principles, we elected to create an equilateral triangle pattern bordered by the linea semilunaris, costal margin, latissimus dorsi, and iliac crest. Subsequently, we elected to utilize ultrasound guidance for needle targets as this area is rich in neurovascular supply. Our needle targets projected in Fig. 1 are multidimensional in nature. Each injection site marked "X" indicates 2 levels of injection in each of the oblique abdominal wall muscle bodies. Evidence in literature indicates that for every 2 U/0.1 mL-injection, the affected surface area will range from 3 to 7 cm^2 (14). Therefore, the injection pattern utilized had maximal overlap and muscle paralysis effects from each injection

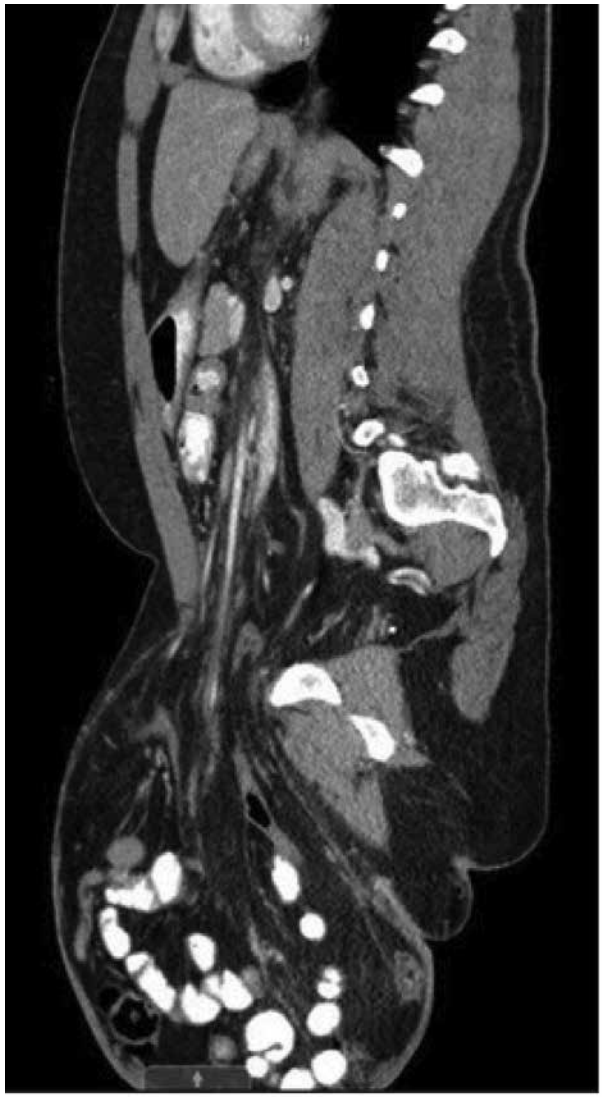

Fig. 2. Preoperative CT scan. Sagittal view from CT abdomen-pelvis scan is notable for herniation of bowel contents into the inguinal hernia sac with abdominal compartment loss of domain.
Abbreviation: CT, computed tomography

Fig. 3. Postoperative CT scan. Midline sagittal view from postoperative CT scan demonstrates bowel content successfully reduced into the abdominal cavity.
Abbreviation: CT, computed tomography

site. Studies have used computed tomography scans to measure hernia size defects before and after BTA injection to identify overall hernia reduction and to test for effectiveness of the intervention, which ranges from 2.3 to 6 cm in length (1,4,14,15). This was not performed in the current patient due to patient preference. Furthermore, use of serial peak expiratory force measurements may evaluate procedural effectiveness.

While data supports the use of BTA injections, they were unlikely the sole factor that allowed for complete primary surgical closure. The combination of multiple factors, such as judicious intraoperative crystalloid administration and limited third spacing, along with length of procedure, may also play an important role in surgical success.

The safety profile of BTA injections is similar to that of fascial plane blocks such as the transversus abdominus plane (TAP), quadratus lumborum, or pectoralis blocks, which afford a relatively high safety margin with only very rare complications noted (16). One major concern was for potential systemic absorption; however, studies have shown a broad therapeutic window and advantageous effects profile (2,17-19). One study described a limited number of complications that include chronic pain and wound complications (19). However, there was no evidence of direct causality in this study and the complications could be attributed to a number of factors (19). This procedure may impair peak expiratory force and cough ability following near complete abdominal wall relaxation. In patients with concomitant severe respiratory pathology, the procedure may be contraindicated. Notably, the patient in the current report had a very thin transversus abdominus muscle body bilaterally, which raised concern for risk of accidental intraperitoneal injection. While some studies injected all 3 muscle groups of the external oblique, internal oblique and transversus abdominis, Ibarra-Hurtado and colleagues (15) injected the external and internal oblique muscles only, with successful outcomes; thus our team felt it acceptable to perform a similar injection depth while avoiding accidental intraperitoneal injection.

BTA injection is well tolerated, requires minimal to no systemic sedation, and patients can be discharged soon after procedure completion. Some studies suggest a reduction in postoperative pain with BTA injections, which may be another advantage to its use (5,20). Patients also demonstrate high rates of satisfaction with the procedure to augment their surgical outcome (11).

CONCLUSION

In summary, abdominal wall BTA injection prior to major abdominal surgery is an effective technique used to facilitate flaccid paralysis of the abdominal musculature. When considering BTA therapy for abdominal muscle relaxation augmentation, the choice of injection pattern should include points of maximum tension and injections of close enough proximity for BTA spread and overlap to maximize procedure benefit, regardless of

the location or type of abdominal wall hernia repair. After thorough discussion with surgical colleagues regarding referral, consider offering this procedure to patients at high risk for incomplete abdominal closure and associated morbidity.

Author Contributions

The following authors contributed as follows to this case report: RMM writing, editing, research, figure composition; RWK writing, editing, research; TK writing, editing, research; RXP writing, editing, research; PEH writing, editing, research.

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