Preoperative abdominal muscle elongation with botulinum toxin A for complex incisional ventral hernia repair

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botulinum toxin A, component separation, incisional hernia, lateral abdominal wall, preoperation.

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Abstract

Background: Surgical repair of recurrent abdominal incisional hernia(s) can be challenging due to complex operative conditions, intense post-operative pain, potential respiratory compromise and lateral muscle traction predisposing to early recurrence. We report our preliminary results with botulinum toxin A (BTA) injection causing flaccid paralysis (relaxation) of the lateral abdominal wall muscles prior to surgery.

Methods: A prospective pilot study measured the effect of preoperative BTA prior to elective repair of recurrent abdominal hernias. Under ultrasound control, 2 weeks prior to surgery, 50 units of BTA was injected into the external oblique, internal oblique and transversus abdominis muscles at three sites on each side of the lateral abdominal wall (total dose 300 units). Pre- and post-BTA abdominal computed tomography measured changes in abdominal wall muscle thickness and length. All hernias were repaired with mesh in a single or two-staged procedure.

Results: Eight patients received BTA injections which were tolerated with no complications. Post-BTA preoperative computed tomography showed a significant increase in mean length of lateral abdominal wall from 18.5 cm pre-BTA to 21.3 cm post-BTA ($P = 0.017$) with a mean unstretched length gain of 2.8 cm per side (range 0.8–6.0 cm). All hernias were surgically reduced with mesh without early recurrence.

Conclusion: Preoperative BTA injection prior to complex abdominal hernia repair is a safe procedure that causes flaccid relaxation, elongation and thinning of the lateral abdominal muscles and decrease in hernia defect. Although further evaluation is required, BTA injections may be a useful adjunct to surgical repair of complex incisional hernias.

Introduction

Incisional hernias occur in up to 15% of all patients undergoing abdominal surgery.¹ Repair is often complex and associated with high rates of morbidity and failure.²–⁴ Reported recurrence rates, within 36 months, in recent studies vary between 15 and 21% for open repair and between 7 and 15.5% for laparoscopic repair⁵ and as high as 56%, 47% and 48% after first, second and third hernia repairs.⁵ Despite innovation in surgical techniques, such as the introduction of surgical mesh and component separation, there have been minimal improvements in post-operative morbidity and hernia recurrence.²,⁶,⁷

Botulinum toxin A (BTA) is a neuromodulating agent that is used for an increasing number of clinical applications including dystonia, spasticity, cerebral palsy, hyperhidrosis, hypersalivation, bladder dysfunction, skin wrinkles and pain management over the last 40 years.⁸,⁹ There are now a small number of case reports, in both humans and animals, using BTA for the perioperative management of abdominal wall surgery with the aims of: (i) improving analgesia,¹⁰ (ii) using the flaccid relaxation to lengthen the abdominal...
oblique muscles and facilitate apposition of the edges of the defect akin to the effect of component separation\textsuperscript{11} but without disrupting the fascial integrity of the abdominal wall; and (iii) decreasing lateral traction and thus reducing tension before and after surgical repair.\textsuperscript{12,13}

The aim of this preliminary study was to measure the effect on abdominal oblique muscle length and thickness following preoperative BTA preparation for elective surgical repair of recurrent complex incisional hernias.

**Methods**

This was a single-centre prospective study of patients who underwent preoperative BTA abdominal wall injections prior to elective surgical repair of a recurrent incisional hernia from October 2012 to May 2013. All patients had large complex incisional hernias with a minimum domain loss of 15\% or minimum linear defect length of 6 cm as a single defect or sum of multiple smaller defects, as measured on abdominal computed tomography (CT). All patients had failed at least two previous repairs of their incisional hernias.

Each patient underwent abdominal wall BTA (onabotulinumtoxinA, BOTOX, Allergan, Gordon, NSW, Australia) injection 2 weeks prior to surgery in an outpatient setting. Each patient received 300 units of BTA in 150 mL 0.9\% saline per patient (2 units/mL). Injections were divided into six equal volumes of 25 mL. The patient was placed in a lateral position and using high resolution ultrasound guidance, three sites were identified and marked along the anterior axillary line equidistant between the inferior border of the rib cage and anterior superior iliac spine, according to positions identified by Smoot \textit{et al.}\textsuperscript{10} Using aseptic technique, each injection site was anesthetized with 1\% lignocaine to dermis and subdermis. A 23-G spinal needle attached to a 25-mL syringe and extension tubing was used to inject 8 mL of diluted BTA under real-time ultrasound control into each muscle belly of transversus abdominis, internal oblique and external oblique, in order, at each site. The process was repeated on the contralateral side. The patients were observed for 30 min and then allowed to return to normal activities until time of surgery.

At surgery, patients underwent laparoscopic or laparoscopic-assisted mesh hernia repairs using standard surgical techniques in accordance with a specially devised surgical decision algorithm (Fig. 1). All patients had SepraMesh IP (CR Bard, Cranston, RI, USA) cut to size and secured with a transfacial inlay technique. All surgery was performed by the same surgeon (NI).

Patients underwent non-contrast abdominal CT examination at (i) initial assessment; (ii) post-BTA injections and prior to surgery; (iii) 6–8 weeks post-surgery; (iv) 9 months post-surgery or as clinically indicated. Measurements of lateral abdominal wall muscle thickness and transverse abdominal wall ‘unstretched length’ on each side were made from a single resting axial CT image at the same vertebral level on each occasion (Figs 2,3). Lateral abdominal wall muscle thickness was measured from the superficial surface of external oblique to deep surface of transversus abdominis at the approximate level of the mid-axillary line. Transverse abdominal wall length on each side was measured along the inner surface of the abdominal muscle complex from lateral edge of quadratus lumborum to medial edge of rectus abdominis.

**Fig. 1.** Perioperative surgical decision-making algorithm.

This algorithm is individualized for each patient undergoing preoperative botulinum toxin A and laparoscopic incisional hernia surgery. To date, all patients have successfully undergone laparoscopic/laparoscopic-assisted reduction and repair of their incisional hernias. Two patients required a staged procedure due to enterotomies (one planned and one unplanned) made during the dissection of the adhesions/hernia sac.

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The difference in lateral abdominal wall length pre- and post-BTA injections was analysed using the Student’s t-test in XLstat (Addinsoft, New York, NY, USA) with significance at $P < 0.05$.

**Results**

Eight patients (six males/two females) underwent abdominal wall BTA injections. Seven patients had midline recurrent hernias and one had a recurrent right-sided ventral hernia, which had received the BTA injections on the ipsilateral side. The mean age was 62 years (range 47–83 years) and the smallest defect size was $5 \times 9$ cm while the largest was $24 \times 24$ cm (Table 1).

All patients showed an increase in abdominal circumference at 7 days post-BTA injections (Figs 2,3). The most common side effect reported by patients was ‘bloatedness’ as the abdominal wall muscles lengthened and relaxed. The temporary flaccidity of the lateral abdominal wall also resulted in a few patients reporting a weaker cough and sneeze. This was aided by the use of an abdominal binder to support. All patients return to their normal daily activities prior to surgery.

A comparison of CT scans before and after BTA injection showed an increased abdominal muscle length (Fig. 2) and decrease in lateral abdominal wall thickness by a mean of $6.3 \text{ mm}$ (range 0.4–13.5 mm). In patients with midline hernias ($n = 7$), when each side was added together, the mean increase in lateral...
abdominal wall length prior to surgery was 6.2 cm (range 3.0–10.8 cm) (Table 1). The reduction of abdominal contents into intra-abdominal cavity, including solid organs, prior to surgery was observed in several patients (Fig. 2).

All patients had their incisional hernias successfully reduced and repaired using laparoscopic or laparoscopic-assisted assisted repair with an intra-abdominally placed and secured mesh. Intraoperative bowel complications occurred in two patients, including an incidental enterotomy in one and an expected small bowel resection in another who had suffered multiple small bowel obstructions prior to hernia repair. Both had previously undergone seven surgical procedures for management of their incisional hernias and required staged procedures as per the algorithm (Fig. 1). Post-operatively, these two patients required a period of ventilation in an intensive care unit. The remainder were successfully extubated and managed with non-invasive oxygen support. There was no mortality but there was one unplanned return to the operating theatre for repair of an anastomotic leak and removal of mesh in the patient who had undergone bowel resection. All patients were well enough for discharge home between day 7 and 11 post-operation, except the two patients with stage repairs who had prolonged hospitalizations. The flaccid relaxation of the lateral abdominal muscles persisted for more than 2 months with all patients asymptomatic of the recovery of the motor activity of these muscles.

### Discussion

BTA has been used for over 40 years for an increasing number of spastic muscle disorders and more recently pain management. Once injected, BTA binds with high affinity to glycoproteins on the cholinergic nerve terminals at the neuromuscular junction and subsequently internalized. Once internalized, the light chain of the BTA molecule prevents the synapse of the acetylcholine vesicles and results in temporary blockade of cholinergic neuromuscular transmission resulting in flaccid paralysis of the target muscle. Clinically, the effects become apparent in 2–3 days, with full effect by 2 weeks and decline after 11–12 weeks. We hypothesize that, in the case of the lateral abdominal wall, the loss of resting muscle tone results in muscle thinning and elongation that allows for a more anatomic surgical approximation of the margins of a ventral hernia defect.

To date, there is a single animal study and a small number of reports of abdominal wall BTA injections being used in abdominal wall surgery. An initial study in rats demonstrated that abdominal wall BTA resulted in increased mean abdominal volume and decreased abdominal wall muscle motor activity with no respiratory compromise compared with controlled animals. The first reported use of abdominal wall BTA in adult humans was in 12 patients for management of open abdominal wounds after damage control laparotomy. Using abdominal wall electromyography guidance, 50 units BTA was injected into five sites on each side (250 units per side, 500 units in total) 4 weeks prior to planned closure of the open abdomen. Abdominal CT post-BTA prior to surgery showed a mean decrease in hernia size of 5.25 cm, similar to results reported by us. Surgical closure was achieved in all cases, five required surgical component separation with no recurrence at 9 months. Similarly, a more recent report of nine patients with open abdomens used 300 units of BTA into the abdominal wall within 24 h of salvage surgery resulting in the open abdominal wound. Delayed fascial closure was achieved in 83% of patients and partial fascial closure of 6%, although length of delay to closure, size of defects and surgical techniques were not documented.

There are also case reports of abdominal wall BTA being used for post-operative pain management in a patient after incisional hernia repair, intra-abdominal hypertension/abdominal compartment syndrome in critically ill patients and management of abdominal wall closure in neonates with gastroschisis.

In this preliminary study, BTA was used for the preoperative preparation of the lateral abdominal wall in patients suffering complex incisional hernias. All patients tolerated the preoperative BTA injections as a single outpatient procedure with no preoperative complications that could include haematoma, pain, allergic response, rash or injection failure. Laparoscopic or laparoscopic-assisted mesh hernia repair was achieved in all patients. The flaccid relaxation due to BTA injections resulted in thinning and lengthening of the lateral abdominal wall with a mean unstretched length gain of 2.8 cm per side which is comparable with the increase in abdominal wall length after surgical component separation. However, with this technique, muscle integrity is maintained, preserving all surgical options including open and laparoscopic repair, component separation and the use of surgical mesh.

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**Table 1: Abdominal computed tomography measurements of lateral abdominal wall length pre- and post-botulinum toxin A (BTA) injections**

<table>
<thead>
<tr>
<th>Patient number</th>
<th>Hernia size (horizontal × vertical, cm)</th>
<th>Pre-BTA Length – Left (cm)</th>
<th>Post-BTA Length – Left (cm)</th>
<th>Difference</th>
<th>Pre-BTA Length – Right (cm)</th>
<th>Post-BTA Length – Right (cm)</th>
<th>Difference</th>
</tr>
</thead>
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<tr>
<td>PT-1</td>
<td>10 × 7</td>
<td>24.5</td>
<td>26.4</td>
<td>1.9</td>
<td>22.9</td>
<td>24.0</td>
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<td>PT-2</td>
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<td>24.3</td>
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<td>21.0</td>
<td>24.1</td>
<td>3.1</td>
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<tr>
<td>PT-3</td>
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<td>17.0</td>
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<td>4.8</td>
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<td>22.2</td>
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</tr>
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<td>14.7</td>
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<td>2.6</td>
<td>18.3</td>
<td>22.4</td>
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</tr>
<tr>
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<td>24.1</td>
<td>2.1</td>
<td>22.0</td>
<td>24.4</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Results for the first eight patients undergoing preoperative BTA therapy. The abdominal wall length was measured from a non-contrast computed tomography scan prior to BTA injections and 7–10 days post-BTA injections prior to surgical repair. Each measurement was made from the lateral edge of the quadratus lumborum muscle to the medial (free) edge of the rectus muscle from a comparable axial image at the same spinal level. BTA injections were performed and measured on both sides for midline defects (n = 7), but only measured on one ipsilateral side in a patent right-sided lateral ventral hernia (PT-4). NA, not applicable; PT, patient.
Abdominal wall BTA has not been reported in patients undergoing elective incisional hernia repair in the English literature. This preliminary study has demonstrated that the use of preoperative abdominal wall BTA is a safe, well-tolerated procedure resulting in flaccid relaxation of the lateral abdominal wall. CT imaging demonstrated a significant increase in mean ‘unstretched’ length of the lateral abdominal wall muscles of 2.8 cm per side. This degree of abdominal wall lengthening is comparable with component separation, but does not disrupt the anatomical integrity of the abdominal wall thus preserving all surgical options for repair.

Flaccid relaxation and decreased lateral abdominal wall tension may also facilitate the increased ease of intraoperative hernia reduction and post-operatively may minimize tension on the surgical repair during the acute healing phase. In addition, the flaccid relaxation of the lateral abdominal wall muscles may decrease intra-abdominal pressure, improving ventilation compliance thus decreasing the need for and duration of invasive ventilation support. Longitudinal studies are underway to assess the ideal dose and timing of preoperative BTA treatment as well as the additional benefits of preoperative BTA in the surgical management for complex incisional hernias.

References