Background and Objectives: Fascial plane blocks are rapidly emerging to provide safe, feasible alternatives to epidural analgesia for thoracic and abdominal pain. We define a new option for chest wall and upper abdominal analgesia, termed the rhomboid intercostal and subserratus plane (RISS) block. The RISS tissue plane extends deep to the erector spinae and abdominal analgesia, termed the rhomboid intercostal and subserratus plane (RISS) block. We hypothesized that the rhomboid intercostal block can be extended caudally by position- ing the needle tip deep to the serratus major muscle, as well as the tissue plane deep to the rhomboid major muscle, as well as the tissue plane deep to the serratus anterior muscle.

METHODS

Cadaveric Study

Six unembalmed (fresh) adult cadavers representing a range of body habitus and both sexes were chosen. Cadavers with known thoracic deformities or previous spine surgery were excluded from the study. All cadavers were maintained at room temperature for 12 hours before injection. Bilateral ultrasound-guided RISS blocks were performed on each cadaver (n = 12 injections) by one investigator (H.E.).

Description of the Technique

The cadaveric specimens were placed in the prone position, with both arms abducted and internally rotated to move the inferior angle of the scapula laterally. A linear ultrasound transducer (6–12 MHz Mindray M7 diagnostic ultrasound system; Mindray DS USA Inc, Mahwah, New Jersey) was placed in the sagittal plane medial to the medial border of the scapula with the orientation...
marker directed cranially. The transducer was then rotated so the cranial end was directed slightly medially and the caudal end laterally to produce an oblique sagittal view (paramedian sagittal oblique) approximately 1 to 2 cm medial to the medial scapular border (Fig. 1A).

The following structures were identified from superficial to deep: trapezius muscle, rhomboid major muscle, intercostal muscles between ribs, pleura, and lung. The tissue plane between the rhomboid major and intercostal muscles was identified. A 17-gauge Tuohy needle was advanced in plane from a superomedial-to-inferolateral direction, through the trapezius and rhomboid major muscles. Ten milliliters of 0.5% methylcellulose with India ink was injected in the fascial plane between the rhomboid major muscle and the intercostal muscles. The skin entry point for the first injection was at the T5–T6 level just medial to the scapula (Fig. 1, B and C; Video 1, Supplemental Digital Content 1, http://links.lww.com/AAP/A267). Two landmarks verified identification of the T5–T6 level: (1) counting down from the C7 spinous process and (2) identifying the medial part of the spine of the scapula at the T3 level.

Next, to identify the subserratus plane, the transducer was moved caudally and laterally, distal to the inferior angle of the scapula behind the posterior axillary line (Fig. 2, A–C). Tissue layers were identified from superficial to deep: latissimus dorsi, serratus anterior, intercostal muscles between ribs, pleura, and lung (Muscle Layers, Supplemental Digital Content 2, http://links.lww.com/AAP/A268). The needle was inserted at the same skin entry site as was used for the rhomboid intercostal injection but directed caudally and laterally beyond the inferior angle of the scapula. If the needle tip did not reach beyond the inferior edge of the scapula (eg, obese and tall habitus), a new skin entry point medial to the lower angle of the scapula and posterior axillary line was used. Twenty milliliters of 0.5% methylcellulose with India ink was injected in the tissue plane between the serratus anterior and external intercostal muscle, hydrodissecting the tissue plane between the serratus anterior muscle and the attachments of the serratus to the rib (Video, Supplemental Digital Content 3, http://links.lww.com/AAP/A269). The same procedure was repeated on the contralateral side.

**Cadaveric Anatomic Dissection**

The chest walls were dissected in layers from superficial (posterior) to deep (anterior) by an anatomist (R.L.D.) 2 hours following the injection. The detailed cadaveric dissection is available
as supplemental material (Cadaveric Clarification, Supplemental Digital Content 4, http://links.lww.com/AAP/A270, and Supplemental Digital Content 5, http://links.lww.com/AAP/A271). We dissected the trapezius from its attachment on the spine processes to expose the rhomboid major and minor muscles. Next, the latissimus dorsi muscle was reflected laterally. The erector spinae muscles were then reflected cranially to identify the thoracic transverse processes and the origins of the dorsal rami.

The lateral cutaneous branches of the intercostal nerves were identified at the midaxillary line in the tissue plane deep to the serratus anterior muscle. Subsequently, ribs T2 to T12 were removed at the articular surface of the transverse processes to visualize any staining in the intercostal spaces.

The axillary space was identified between the pectoralis minor muscle anteriorly and subscapularis muscle posteriorly. Below the eighth thoracic level, the upper part of the external oblique muscle was identified and removed to identify the tissue plane located superficial to the external intercostal muscles and traversing around the anterior axially line. All key steps of the dissection were photographed.

Clinical Case Series

The Cleveland Clinic Institutional Review Board approved a retrospective review of cases performed between April 2016 and August 2017. Written informed consent for the nerve block procedures were obtained from all patients. Patients were positioned in the lateral decubitus position with the painful/operative side up and monitored with standard American Society of Anesthesiologists monitoring. A rhomboid intercostal injection was performed using a 17-gauge Tuohy needle utilizing the same technique as described above in the cadaveric study. Five to 10 mL of local anesthetic (0.5% ropivacaine or bupivacaine) was administered to patients receiving a single-shot block or 5 to 10 mL of 0.2% ropivacaine in patients receiving catheters. The target landmark was the plane located superficial to the intercostal muscles. The injectate was visualized to spread both cranially and caudally throughout the subserratus tissue plane, noting the injectate volume pushing the serratus anterior muscle away from the external intercostal muscle (External Photos, Supplemental Digital Content 6, http://links.lww.com/AAP/A272).

In subjects undergoing a continuous infusion, a 19-gauge, 40-cm catheter (Arrow by Teleflex; Teleflex, Morrisville, North Carolina) was then introduced into the subserratus plane and advanced 3 to 5 cm beyond the needle tip. The catheter tip position was confirmed with injection of 5 mL of 0.2% ropivacaine under direct ultrasound visualization (Video, Supplemental Digital Content 7, http://links.lww.com/AAP/A273). Catheters were secured with sterile adhesive dressing.

Additional outcome data were obtained from the electronic medical record including the extent of sensory dermatomal coverage as determined by a loss of cold sensation to ice, duration of analgesia, and pain scores using visual analog score before and after the block.

RESULTS OF THE CADAVERIC STUDY

Six cadavers were included in the study (3 male, 3 female) with body mass indices between 28 and 44 kg/m². We identified the tissue plane between the rhomboid major and minor muscles, serratus anterior muscle, external intercostal muscle, and external oblique muscles from T2 to T12. In addition, we identified the lateral branches of the intercostal nerves from T2 to T12 and dorsal rami deep to the erector spinae muscle at midline.

We observed staining of the subserratus tissue plane from T2 to T9 and variable staining of the lateral branches of the intercostal nerves from T2 to T10 (see below) (Fig. 3A). Contrast was observed coursing medially, reaching the location of the exiting posterior primary rami deep to the erector spinae muscle (Fig. 3B). Cranially, contrast staining deep to the rhomboid major and minor stopped at the levator scapula muscle in all specimens and was not observed beyond the serratus posterior superiorly, in proximity to the T2 level. Laterally and cranially, contrast extended to the clavicular fascia inside the axilla in 7 specimens (Fig. 3C), and inferiorly to the level of T10 around the insertion of the serratus posterior inferior muscle and origin of the external oblique muscle in 10 specimens (Fig. 3C).

**FIGURE 3.** A, Cadaveric dissection showing spread of blue dye injectate in the subserratus tissue plane and staining of the lateral branches of the intercostal nerves. LCB indicates lateral cutaneous branches of intercostal nerves; SA, serratus anterior muscle. B, Cadaveric dissection showing spread of blue dye injectate in the tissue plane deep to the erector spinae muscle (ES) staining the T6 and T7 dorsal rami of the spinal nerves (DR). C, Cadaveric dissection showing spread of blue dye injectate in the floor of the axilla, deep to the serratus anterior muscle (SA) up to the level of the second rib and dye reaching inferiorly to T10 around the insertion of the inferior portion of the serratus posterior muscle (SP) and origin of the external oblique muscle (EO). LCB indicates lateral cutaneous branches of intercostal nerves; LD, latissimus dorsi muscle.
The lateral branches of the intercostal nerves stained consistently across all specimens from T4 to T8. Ten specimens demonstrated consistent staining of T2 and T3. Nine specimens demonstrated consistent staining of T9 and T10 deep to the upper slips of the external oblique muscle (Fig. 4). Below the eighth thoracic level the lower 4 slips of the serratus anterior muscle interdigitate at their origins with the upper 5 slips of the external oblique muscle.25 Also below the eighth thoracic level, the serratus anterior muscle ends and this tissue plane becomes deep to the latissimus dorsi and the upper part of the external oblique muscle.

In 8 specimens, faint staining of the tissue plane deep to the erector spinae muscles from T4 to T8 was observed and continued to the tissue plane posterior to the thoracic transverse processes. In 4 specimens, staining stopped at the lateral edge of the erector spinae, and no staining was observed deep to the erector spinae muscle (Cadaveric Clarification, Supplemental Digital Content 4, http://links.lww.com/AAP/A270).

We were able to identify the dorsal rami of the thoracic intercostal nerves of T6 and T7 as they emerge between the tips of adjacent transverse processes in only 2 cadavers (Fig. 3B). No specimens demonstrated intercostal nerve staining within the intercostal spaces either anteriorly or posteriorly. Staining was seen in the floor of the axilla in nine specimens, deep to the serratus anterior muscle up to the level of the second rib and posterior to the clavipectoral fascia. In 2 of these 9 specimens, there was faint staining within the axilla and around the axillary artery. No staining was observed within the axilla in 3 specimens. We did not identify the lateral pectoral, medial pectoral, long thoracic, or thoracodorsal nerves (summarized in Fig. 4). We did not observe any evidence of epidural or paravertebral spread.

PATIENT OUTCOMES

This case series included 15 patients. Clinical data are summarized in Table 1. Four patients received single-shot blocks, and 11 patients received continuous catheters. Indications were either incisional or nonincisional pain of the chest wall, including rib fracture (2 patients), chest tube (2 patients), upper abdominal surgery (7 patients), cancer pain (1 patient), lung transplant (2 patients), and pneumonectomy (1 patient). The points of injection were tailored to the anatomic location of pain, with rhomboid intercostal injection points ranging from T3 to T6 and subserratus plane injection point ranging from T4 to T10 (Fig. 5, A and B).

Dermatomal cold sensory deficits were consistently achieved from T5 to T9, with the most cephalad coverage to T2 and the most caudal coverage to T12. The dermatomal coverage included the anterior hemithorax extending from 4 cm lateral of the midline at the medial extent, laterally to the axilla, and on the posterior hemithorax extending to the midscapular line 4 cm medial to the posterior axillary line. Data for pain scores before the procedure, mean pain scores measured after block, and the dermatomal levels covered in patients are listed in Table 1. The average duration of analgesia for single-shot blocks was 16 hours, and the average duration of catheter infusion was 3.6 days. No patients experienced any adverse reactions resulting from the blocks or catheters, including pneumothorax, hypotension, urinary retention, upper or lower extremity weakness, or insertion site bleeding or infection (Detailed Patients Management, Supplemental Digital Content 8, http://links.lww.com/AAP/A274).

DISCUSSION

We demonstrate that injection in the tissue plane located between the rhomboid and intercostal muscles and then deep to the scapula and serratus anterior muscle targets the lateral cutaneous branches of the ventral rami of thoracic intercostal nerves. Spread extends medially deep to the erector spinae tissue plane and superficial to the thoracic transverse processes at the point where the dorsal rami of the thoracic intercostal nerves emerge between the tips of adjacent transverse processes T3 to T9.

In addition, we provide cadaveric evidence that the tissue plane deep to the erector spinae muscle, rhomboid muscles, serratus anterior muscles, latissimus dorsi, and the upper part of the external oblique muscle is continuous. To our knowledge, this has not been described as one continuous tissue plane.

The RISS block leads to reproducible dermatomal analgesic coverage of the thorax upper abdomen and can be useful for cancer pain, postoperative pain after thoracotomy, chest tube–associated pain, rib fracture pain, and upper abdominal incisional pain and as a supplement to a patchy thoracic epidural. We observed no extension to the intercostal nerves. The thoracodorsal and long thoracic nerves lie superficial to the serratus anterior muscle and should therefore be spared using the RISS block.

In the cadaveric component of the study, we noted less consistent spread to the dorsal rami which is congruent with results of the clinical component of the study wherein the posterior midline area was not blocked consistently in all patients.

Given that this injection is made into an interfascial plane, the final needle location for injection can be varied, depending on desired dermatomal coverage. Specifically, the rhomboid intercostal plane injection can be made anywhere from approximately T3 to T6 (rhomboid major and minor muscles originate at the C7–T5 spinous processes medially and course inferolaterally to insert at the medial border of the scapula at the T2 to T6 level), and the subserratus plane injection can be made anywhere from approximately T4 to T10 (serratus anterior muscle originates at the T1–T9 ribs and inserts along the medial border of the scapula). The rhomboid intercostal tissue plane overlaps with the subserratus tissue plane laterally and communicates from T1 to T5.

We posit that the RISS combination block can be considered as an alternative approach to, or modification of, the serratus
<table>
<thead>
<tr>
<th>Patient</th>
<th>Pathology</th>
<th>Technique</th>
<th>RI Injectate*</th>
<th>RI Location</th>
<th>SS Injectate*</th>
<th>SS Location</th>
<th>Dermatomal Coverage</th>
<th>Visual Analog Score (Pre → Post)</th>
<th>Duration of Analgesia</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 81/M</td>
<td>T4–T8 rib fractures</td>
<td>Block</td>
<td>10 mL</td>
<td>T6</td>
<td>10 mL</td>
<td>T9</td>
<td>T2–T9</td>
<td>10 → 2</td>
<td>12 h</td>
</tr>
<tr>
<td>2. 64/F</td>
<td>Chest tube × 2</td>
<td>Block</td>
<td>10 mL</td>
<td>T6</td>
<td>20 mL</td>
<td>T9</td>
<td>T4–T10</td>
<td>9 → 2</td>
<td>12 h</td>
</tr>
<tr>
<td>3. 77/F</td>
<td>Chest tube × 2</td>
<td>Block</td>
<td>10 mL</td>
<td>T6–T7</td>
<td>10 mL</td>
<td>T9</td>
<td>T3–T8</td>
<td>10 → 4</td>
<td>16 h</td>
</tr>
<tr>
<td>4. 69/M</td>
<td>Subcostal incision</td>
<td>Block</td>
<td>10 mL</td>
<td>T6</td>
<td>10 mL</td>
<td>T10</td>
<td>T5–T10</td>
<td>10 → 2</td>
<td>24 h</td>
</tr>
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</table>

**Single-shot blocks**

<table>
<thead>
<tr>
<th>Patient</th>
<th>Pathology</th>
<th>Technique</th>
<th>RI Injectate*</th>
<th>RI Location</th>
<th>SS Injectate*</th>
<th>SS Location</th>
<th>Dermatomal Coverage</th>
<th>Visual Analog Score (Pre → Post)</th>
<th>Duration of Analgesia</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. 42/F</td>
<td>Ventral hernia repair</td>
<td>Catheter</td>
<td>10 mL</td>
<td>T6</td>
<td>10 mL</td>
<td>T6–T7</td>
<td>T4–T9</td>
<td>8 → 3</td>
<td>4 d</td>
</tr>
<tr>
<td>6. 57/F</td>
<td>VATS, pneumonectomy, and 6th rib resection</td>
<td>Catheter</td>
<td>10 mL</td>
<td>T4–T5</td>
<td>10 mL</td>
<td>T6–T7</td>
<td>T4–T9</td>
<td>9 → 3</td>
<td>4 d</td>
</tr>
<tr>
<td>7. 51/M</td>
<td>Cancer pain at T3–T6 right lateral chest wall</td>
<td>Catheter</td>
<td>10 mL</td>
<td>T4–T5</td>
<td>10 mL</td>
<td>T6–T7</td>
<td>T3–T9</td>
<td>10 → 2</td>
<td>2 d</td>
</tr>
<tr>
<td>8. 41/F</td>
<td>Open cholecystectomy</td>
<td>Catheter</td>
<td>10 mL</td>
<td>T6</td>
<td>10 mL</td>
<td>T8</td>
<td>T5–T12</td>
<td>10 → 4</td>
<td>5 d</td>
</tr>
<tr>
<td>9. 92/F</td>
<td>T4–T7 rib fractures</td>
<td>Catheter</td>
<td>20 mL</td>
<td>T3–T4</td>
<td>15 mL</td>
<td>T6–T7</td>
<td>†</td>
<td>10 → 2‡</td>
<td>2 d</td>
</tr>
<tr>
<td>10. 77/M</td>
<td>Open pancreaticoduodenectomy</td>
<td>Bilateral catheters</td>
<td>10 mL per side</td>
<td>T5</td>
<td>10 mL per side</td>
<td>T7–T8</td>
<td>Right: T6–T10 Left: T8–T11</td>
<td>9 → 5</td>
<td>2 d</td>
</tr>
<tr>
<td>11. 57/F</td>
<td>Open adrenalectomy</td>
<td>Bilateral catheters</td>
<td>10 mL per side</td>
<td>T5</td>
<td>10 mL per side</td>
<td>T6–T7</td>
<td>Right: T7–T12 Left: T8–T10</td>
<td>2–4 Post§</td>
<td>3 d</td>
</tr>
<tr>
<td>12. 66/M</td>
<td>Left lung transplant</td>
<td>Catheter</td>
<td>10 mL</td>
<td>T3–T4</td>
<td>10 mL</td>
<td>T4–T5</td>
<td>T3–T6</td>
<td>9 → 3</td>
<td>6 d</td>
</tr>
<tr>
<td>13. 57/F</td>
<td>Open adrenalectomy</td>
<td>Bilateral catheters</td>
<td>10 mL per side</td>
<td>T5</td>
<td>10 mL per side</td>
<td>T7</td>
<td>Right: T7–T11 Left: T6–T10</td>
<td>8 → 3</td>
<td>3 d</td>
</tr>
<tr>
<td>14. 65/M</td>
<td>Right lung transplant</td>
<td>Catheter</td>
<td>10 mL</td>
<td>T4</td>
<td>10 mL</td>
<td>T6</td>
<td>T4–T8</td>
<td>9 → 4</td>
<td>4 d</td>
</tr>
<tr>
<td>15. 54/M</td>
<td>Liver wedge resection</td>
<td>Bilateral catheters</td>
<td>10 mL per side</td>
<td>T5</td>
<td>10 mL per side</td>
<td>T8</td>
<td>Right: T7–T11 Left: T6–T10</td>
<td>7 → 0</td>
<td>5 d</td>
</tr>
</tbody>
</table>

*For patients receiving single-shot blocks, 0.5% bupivacaine was injected; for patients receiving a catheter, ropivacaine 0.2% was injected as a bolus through the needle with the volume listed here followed by an infusion of ropivacaine 0.2% at a basal rate of 4 to 8 mL/h and a bolus of 6 to 12 mL every 60 minutes through RI catheters.

†Unable to attain due to language barrier.

‡Using FACES scale, interpreter, and daughter interpretation due to language barrier.

§Block was performed under general anesthesia; therefore, preprocedure pain score is not applicable.

RI indicates rhomboid intercostal; SS, subserratus plane; VATS, video-assisted thoracoscopic surgery.
FIGURE 5. A, Computed tomography with reconstructed 3-dimensional image demonstrating the RISS catheter tip located at the midaxillary line adjacent to T10. B, Computed tomography scan with reconstructed 3-dimensional image demonstrating catheter insertion point at the level of T7 at a point medial to the inferior edge of the scapula and deep to the latissimus dorsi and serratus anterior muscles. The tip of the catheter is positioned near the midaxillary line at approximately the T10 level. These images are of patient 5 from Table 1 who had RISS catheter placed for inadequate T8-9 epidural coverage.

Conclusions
This initial description and evaluation of the RISS block demonstrates the concept of continuity between chest wall fascial planes with consistent spread of injectate to the lateral cutaneous branches of the T4 to T9 intercostal nerves in cadavers and consistent analgesia from the T5 to T8 dermatomes in a clinical case series, showing promise for this block in providing chest wall and upper abdominal wall analgesia.

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References


