The rectus capitis lateralis and the condylar triangle: important landmarks in posterior and lateral approaches to the jugular foramen

Michael A. Cohen, MD,1,2 Alexander I. Evins, PhD,1 Gennaro Lapadula, MD,1,3 Leopold Arko, MD,1,4 Philip E. Stieg, PhD, MD,1 and Antonio Bernardo, MD1

1Department of Neurological Surgery, Weill Cornell Medical College, New York, New York; 2Department of Neurological Surgery, Rutgers New Jersey Medical School, Newark, New Jersey; 3Department of Neurology and Psychiatry, Neurosurgery, “Sapienza” University of Rome, Italy; and 4Department of Neurological Surgery, Temple University Medical School, Philadelphia, Pennsylvania

OBJECTIVE The rectus capitis lateralis (RCL) is a small posterior cervical muscle that originates from the transverse process of C-1 and inserts onto the jugular process of the occipital bone. The authors describe the RCL and its anatomical relationships, and discuss its utility as a surgical landmark for safe exposure of the jugular foramen in extended or combined skull base approaches. In addition, the condylar triangle is defined as a landmark for localizing the vertebral artery (VA) and occipital condyle.

METHODS Four cadaveric heads (8 sides) were used to perform far-lateral, extended far-lateral, combined transmastoid infralabyrinthine transcervical, and combined far-lateral transmastoid infralabyrinthine transcervical approaches to the jugular foramen. On each side, the RCL was dissected, and its musculoskeletal, vascular, and neural relationships were examined.

RESULTS The RCL lies directly posterior to the internal jugular vein—only separated by the carotid sheath and in some cases cranial nerve (CN) XI. The occipital artery travels between the RCL and the posterior belly of the digastric muscle, and the VA passes medially to the RCL as it exits the C-1 foramen transversarium and courses posteriorly toward its dural entrance. CNs IX–XI exit the jugular foramen directly anterior to the RCL. To provide a landmark for identification of the occipital condyle and the extradural VA without exposure of the suboccipital triangle, the authors propose and define a condylar triangle that is formed by the RCL anteriorly, the superior oblique posteriorly, and the occipital bone superiorly.

CONCLUSIONS The RCL is an important surgical landmark that allows for early identification of the critical neurovascular structures when approaching the jugular foramen, especially in the presence of anatomically displacing tumors. The condylar triangle is a novel and useful landmark for identifying the terminal segment of the hypoglossal canal as well as the superior aspect of the VA at its exit from the C-1 foramen transversarium, without performing a far-lateral exposure.

KEY WORDS rectus capitis lateralis; suboccipital triangle; jugular foramen; far lateral; muscle; anatomy

Large tumors of the jugular foramen with intracranial, intrapetrous, and/or extracranial extensions require the use of extended or combined approaches that provide high cervical exposure necessary for manipulation of the internal jugular vein (IJV).4,9,13 The complex, dense, and deep nature of the jugular foramen and upper lateral cervical regions necessitates the use of precise surgical landmarks to avoid injury to the critical neurovascular structures within.

The rectus capitis lateralis (RCL) muscle is a small deep muscle that connects the transverse process of C-1 (C1TP) with the jugular process of the occipital bone, assists in anterior and lateral bending of the occiput in relation to the cervical spine, and plays a minor role in atlantooccipital...
stability (Fig. 1). The RCL, which lies anterior to the suboccipital triangle and centrally within the jugular foramen and high cervical regions, maintains a constant relationship with the structures exiting the jugular foramen, the IJV within the carotid sheath, and the facial nerve (cranial nerve [CN] VII) as it exits the stylomastoid foramen.

We describe the RCL and its anatomical relationships, and discuss its utility as a surgical landmark for safe exposure of the jugular foramen and its contents in extended or combined skull base approaches. In addition, we define the condylar triangle—formed by the RCL anteriorly, the superior oblique posteriorly, and the occipital bone superiorly—as a landmark for localizing the vertebral artery (VA) and occipital condyle without far-lateral exposure.

Methods

Four preserved cadaveric heads (8 sides) underwent far-lateral, extended far-lateral, transmastoid transcervical, and combined far-lateral transmastoid transcervical approaches to the jugular foramen and the RCL, and its musculoskeletal, vascular, and neural relationships were examined (Figs. 2–4). On 2 of these sides, full anatomical dissections with complete exposure of the jugular foramen were performed (Figs. 5 and 6).

Far-Lateral and Extended Far-Lateral Approach

The jugular foramen was approached posteriorly using the far-lateral and extended far-lateral approaches (Fig. 3). For the far-lateral approach, a horseshoe-shaped incision was made, and the superficial and middle muscle layers were dissected as a myocutaneous flap inferiorly and anteriorly until the mastoid tip was exposed. The suboccipital triangle was identified (Fig. 3A and B). The VA was localized in the suboccipital triangle, and the superior oblique was detached and reflected inferiorly (Fig. 3C). The myocutaneous flap was not reflected past the superior-anterior border of the RCL muscle, the location of the stylomastoid foramen. A lateral suboccipital craniectomy and C-1 laminectomy were performed.

In the extended far-lateral approach, the posterior belly of the digastric muscle was detached from the digastric groove, and the occipital artery was freed and protected. The RCL was then identified under the digastric muscle and occipital artery. The anterior border of the RCL was dissected off the carotid sheath, and the muscle was detached from the jugular process. The jugular process was then removed in order to expose the jugular foramen.

For the purposes of this study, we considered the conventional far-lateral approach as limited by the posterior border of the RCL anterosuperiorly and the extended far-lateral approach as continuing anterior to the RCL into the carotid sheath.

Combined Transmastoid Infralabyrinthine Transcervical Approach

The jugular foramen was approached laterally using the transmastoid transcervical approach. A C-shaped or
reverse S-shaped incision was placed at the asterion and extended down to the posterior border of the sternocleidomastoid muscle. The mastoid was exposed, and the myofascial flap was reflected anteriorly. Upper cervical dissection was performed to reveal the carotid sheath anterior to the RCL. The posterior belly of the digastric muscle was reflected inferiorly, and the RCL was exposed. An infralabyrinthine mastoidectomy was performed, the sigmoid sinus was exposed, the mastoid antrum was opened, and the incus was identified (Fig. 4). The lateral and posterior semicircular canals were identified and skeletonized, and the presigmoid dura and endolymphatic sac were uncovered. The fallopian canal was skeletonized beginning inferiorly to the lateral semicircular canal and continued inferiorly to the stylomastoid foramen. The jugular process was exposed while maintaining control of CN VII, and the jugular bulb and IJV were completely skeletonized. The RCL was dissected off the carotid sheath anteriorly and detached from the jugular process superiorly, the jugular process was drilled, and the jugular foramen was exposed.

**Combined Far-Lateral Transmastoid Infralabyrinthine Transcervical Approach**

The approaches described above were combined to provide exposure of the condylar fossa, jugular bulb within the mastoid, and IJV in the upper cervical region with complete access to the jugular foramen from posterior, lateral, and anterolateral perspectives (Fig. 4).

**Detachment of the RCL and Exposure of the Jugular Process**

To expose the jugular process, the RCL had to be detached from its insertion site on the jugular process. To safely accomplish this, the posterior belly of the digastric muscle was first detached from the digastric groove and then reflected inferiorly and anteriorly to expose the jugular process and anterior border of the RCL. Care was taken to avoid injury to CN VII. At this stage, the occipital artery should be coagulated or preserved and reflected away from the RCL. With the suboccipital triangle exposed, the superior oblique muscle was detached and reflected anteriorly and inferiorly. The posterior wall of the carotid sheath was identified and dissected away from the RCL at the midportion of the muscle. Dissection in the space between the carotid sheath and RCL continued superiorly until reaching the jugular process. Again, care was taken to avoid injury to CN VII, which lies several millimeters anterior to the superior aspect of the RCL. Once the RCL was completely dissected off the carotid sheath, the muscle was detached from the jugular process from anterior to posterior. The jugular process was then safely drilled to expose the jugular foramen (Fig. 4 right).

**Quantitative Measurements**

A 3.5-inch graduated Castroviejo caliper was used to measure the distances between the jugular process and C1TP, styloid process and the RCL, medial turn of the VA and the RCL, cervical internal carotid artery (ICA) and the RCL, CN VII at the stylomastoid foramen and the RCL, and CN IX in the carotid sheath and the RCL on all 8 cadaveric sides. Distances between the RCL and the styloid process, medial turn of the VA, cervical ICA, and CN IX were obtained by measuring the distance between the target structure and the anterior border at the midpoint of the RCL in the craniocaudal plane (midway between the origin and insertion of the muscle), directly adjacent to the IJV. The distance between the RCL and
CN VII was obtained by measuring the distance between the anterosuperior corner of the RCL, at its insertion on the jugular process, and CN VII at its exit from the stylomastoid foramen. The angles formed between the RCL and CN IX, X, and XI within the jugular foramen, and between the RCL and the hypoglossal nerve within the hypoglossal canal, were measured in all specimens with a digital protractor.

**Results**

In all 4 posterolateral approaches, the RCL was clearly exposed within the jugular foramen and high cervical regions and was found to maintain a constant relationship with the structures exiting the jugular foramen, the IJV within the carotid sheath, and CN VII as it exits the stylomastoid foramen.

The RCL borders the extracranial neurovascular compartment of the upper retrostyloid parapharyngeal space traversed by the structures exiting the jugular foramen. This extracranial compartment is a transitional space between the intracranial aspect of the jugular foramen and the cervical carotid sheath. For the purposes of this study, we considered this compartment to be bounded by the occipital condyle medially, the styloid process laterally, the RCL posteriorly, and the opening of the jugular foramen superiorly. The inferior boundary of this area is the point at which the lower CNs diverge and the IJV, ICA, and the vagus nerve (CN X) converge within the carotid sheath. Within the jugular foramen and this extracranial neurovascular compartment, the lower CNs travel several millimeters outside the skull, in extremely close proximity, before the ICA, IJV, and CN X meet and the glossopharyngeal (CN IX), accessory (CN XI), and hypoglossal (CN XII) nerves diverge in separate directions.

**Musculoskeletal Relationships**

The RCL has several notable musculoskeletal relationships when approaching the craniocervical junction from posterolaterally. The RCL originates along the superior and anterior portions of the C1TP and inserts on the jugular process of the occipital bone. The RCL is one of several suboccipital muscles that attach to the C1TP, including the superior oblique that inserts on the occipital bone below the superior nuchal line, the inferior oblique that originates from the spinous process of C-2, and the splenius cervicis that originates from multiple thoracic spinous processes (Fig. 3A). The posterior belly of the digastic muscle inserts several millimeters anterior and lateral to the RCL, while the longissimus capitis—which travels superiorly from its origin in the cervical spine and passes posteriorly behind the C1TP—inserts several millimeters posterior and lateral to the RCL. The superior oblique inserts along the inferior nuchal line, posterior to the insertion of the longissimus capitis, while the splenius capitis has a wide insertion laterally that covers the posterior belly of the digastic, RCL, longissimus capitis, and superior oblique muscles.

The RCL courses superiorly and the inferior oblique courses posteriorly from the C1TP, forming a right angle. The superior oblique bisects this angle as it courses toward its insertion site (Fig. 3A). The RCL, the superior oblique, and a line connecting these 2 muscles along the occipital bone form what we term the condylar triangle (Fig. 3B).

In the 4 heads (8 sides) examined, the jugular process was an average of 17.3 mm (range 17–18 mm) superior to the C1TP, and the styloid process was an average of 6.5 mm (range 6–7 mm) anterior to the anterior aspect of the RCL’s insertion on the jugular process.

**Vascular Relationships**

The RCL maintains relatively constant relationships with several critical vascular structures, including the VA and the jugular venous system. The origin of the RCL overlies the C-1 foramen transversarium, where the ex-
traforaminal portion—between the C-1 foramen transversarium and the dura—of the V₃ segment of the VA courses 90° posteriorly (Figs. 5 and 6). Before entering the dura, the extraforaminal portion of the V₃ segment makes a second 90° turn medially. The average distance from this medial turn to the posterior border of the RCL is 20.3 mm (range 19–22 mm).

The RCL lies directly posterior to the IJV, separated only by the carotid sheath (Figs. 5A and B; 7). The anterior portion of the RCL, as it inserts on the jugular process, covers the posterior aspect of the opening of the jugular foramen. As the IJV turns posteriorly and ascends to form the jugular bulb, it becomes superior to the RCL. The posterior aspect of the opening of the jugular foramen is covered by the IJV, which becomes closer to the RCL as it descends.

Intradurally, CN IX is the most superior of the lower CNs to enter the jugular foramen, and it travels anteriorly through the jugular foramen medial to the intrajugular

Neural Relationships

The first structure located anteriorly to the RCL is CN XI, which lies between the medial aspect of the RCL and the IJV, and is in some cases adherent to the carotid sheath. CN X courses anterior to CN XI and directly medial to the IJV. CN IX is anterior to CN X and is furthest from the RCL. CN XII travels obliquely, anteriorly, and inferiorly, medial to CNs XI, X, and IX.

The anterior aspect of the insertion of the RCL on the jugular process is an average of 1.8 mm (range 1.5–2 mm) from CN VII as it exits from the stylomastoid foramen (Figs. 5B and 6). After exiting the stylomastoid foramen, CN VII courses anteriorly toward the parotid gland, moving away from the RCL as it descends.

Intradurally, CN IX is the most superior of the lower CNs to enter the jugular foramen, and it travels anteriorly through the jugular foramen medial to the intrajugular
The rectus capitis lateralis and condylar triangle

Of the CNs within the carotid sheath, CN IX is the farthest from the RCL with an average distance of 9.2 mm (range 8.5–10 mm) from the top of the RCL. After crossing the plane of the RCL, CN IX courses inferiorly to exit the jugular foramen medial to the styloid process and lateral to the ICA (Figs. 5D and 6).

CNs X and XI originate as rootlets from the medulla, enter the jugular foramen together just inferior to CN IX, and travel anteriorly, lateral to the intrajugular septum, before turning inferiorly to wrap around the jugular process and RCL (Figs. 6B and 7). At the superior aspect of the RCL, the two nerves split. CN XI descends in close proximity to the RCL, just medial to the IJV, and CN X crosses lateral to and then medial to the hypoglossal nerve, as it descends into the neck.

CN XII originates as rootlets from the anterior medulla, enters the hypoglossal canal, and courses anteriorly and superiorly, medial to the jugular process and RCL. CN XII then makes a sharp turn inferiorly, crossing the top of the RCL medially, to join the CNs of the jugular foramen as they enter the carotid sheath (Figs. 6C and 7).

Condylar Triangle

To facilitate identification of the occipital condyle, hypoglossal canal, and VA, we propose a novel triangle that we term the condylar triangle—formed by the RCL anteriorly, superior oblique posteriorly, and a line connecting these muscles along the occipital bone superiorly. This condylar triangle can be opened by detaching the superior oblique to expose the posterior aspect of the occipital condyle (Fig. 3C). The condylar triangle contains the anterior...
The RCL, longissimus capitis, and other paraspinal muscles facilitate stabilization and lateral flexion of the head, during which there is compression of the structures exiting the jugular foramen. The RCL, longissimus capitis, and carotid sheath function as a protective barrier by encircling the IJV and the structures exiting the jugular foramen. This probable protective role of the RCL provides it with very constant neurovascular relationships that can be utilized by the surgeon.

The first descriptions of the RCL as a surgical landmark for the jugular foramen and CN VII were performed by Katsuta et al. and Wen et al. in 1997 in their studies of the jugular foramen and far-lateral approach, respectively. Their findings were further elucidated by Rhoton in 2000 in his studies of the jugular foramen and far-lateral approach. While these authors briefly described the RCL in relation to the jugular process, jugular foramen, and CN VII, we present the first comprehensive cadaveric study of the RCL and its neural, vascular, and musculoskeletal relationships in order to demonstrate the utility of the RCL as an important landmark for avoiding neurovascular injury during approaches to the jugular foramen, and detail the surgical steps necessary to safely expose and detach the muscle. In addition, we propose the condylar triangle as a novel and useful landmark for identifying the occipital condyle, hypoglossal canal, and VA.

The jugular foramen can be approached laterally through the mastoid and the upper neck, posteriorly through the far-lateral approach, anterolaterally through the preauricular infratemporal approach, or anteriorly through an endoscopic endonasal approach. When approaching the jugular foramen anteriorly, the contents of the jugular foramen are encountered prior to the RCL; thus, the relevance of the RCL as a surgical landmark is limited to the posterolateral approaches, including the far-lateral and extended far-lateral, and the lateral approaches described herein, including the combined transmastoid transcervical as well as the combined far-lateral transmastoid transcervical approaches (Fig. 8).

In the conventional far-lateral approach for intracranial pathologies, the RCL can function as the anterior boundary of the approach, separating the far-lateral corridor from the contents of the jugular foramen (Figs. 3A and 8). For extended far-lateral approaches to the jugular foramen, the identification and reflection of the RCL, which overlays the structures exiting the jugular foramen, is the first step in safely exposing the jugular process, the surrounding neurovascular structures, and the carotid sheath. The RCL in this context is especially important in the presence of tumors that laterally displace the closely spaced neurovascular structures exiting the jugular foramen.

When approaching primary lesions of the jugular foramen laterally in the transmastoid infralabyrinthine transcervical approach, the RCL and the structures exiting the jugular foramen are encountered simultaneously (Fig. 4), diminishing the value of the RCL as a landmark for these structures and the carotid sheath. However, the RCL remains a valuable and protective landmark for identifying the jugular process and the VA from lateral and anterolateral trajectories.

**Discussion**

Tumors of the jugular foramen, including glomus tumors, schwannomas, and meningiomas, are rare neurosurgical entities. The complex, dense, and deep nature of this region complicates surgical access and necessitates the use of precise surgical landmarks to avoid injury to critical neurovascular structures, including CNs VII and IX–XII, the ICA, IJV, and VA, especially in the presence of anatomically distorting tumors. The RCL, due to its proximity to the jugular foramen and constant anatomical relationships, can function as a key surgical landmark for early identification of and orientation around these critical structures.

The RCL and its relationship with the IJV was first described by Piffer et al. in 1980, who concluded that the RCL is an important protective structure for the IJV. The
The rectus capitis lateralis and condylar triangle

The condylar triangle—which we define as being formed by the RCL anteriorly, the superior oblique posteriorly, and the occipital bone superiorly—contains the anterior third of the occipital condyle and provides a novel and useful landmark for identifying the terminal artery foramen via the extended far-lateral corridor, wherein identification of the RCL can be clinically helpful, the skin incision must extend into the neck to the anterior border of the C1 foramen transversarium as well as the terminal segment of the hypoglossal canal as well as the superior aspect of the VA at its exit from the C-1 foramen transversarium.

Conclusions

The RCL is an important surgical landmark that allows for early identification of the critical neurovascular structures when performing posterior and/or lateral approaches to the jugular foramen, especially in the presence of anatomically displacing tumors. The condylar triangle is a novel and useful landmark for identifying the terminal segment of the hypoglossal canal as well as the superior aspect of the VA at its exit from the C-1 foramen transversarium.

References

11. Piffer CR, Soares JC, Garcia PJ: [Relations of the rectus capitis lateralis muscle with the first portion of the internal
(Fr)
12. Rhoton AL Jr: The far-lateral approach and its transcondylar,
 supracondylar, and paracondylar extensions. Neurosurgery
14. Wen HT, Rhoton AL Jr, Katsuta T, de Oliveira E: Microsur-
 gical anatomy of the transcondylar, supracondylar, and para-
 condylar extensions of the far-lateral approach. J Neurosurg
  87:555–585, 1997

Disclosures
The authors report no conflict of interest concerning the materi-
 als or methods used in this study or the findings specified in this
paper.

Author Contributions
Conception and design: Bernardo, Cohen, Evins, Lapadula, Arko.
Acquisition of data: Cohen, Evins, Lapadula, Arko. Analysis
and interpretation of data: Bernardo, Cohen, Evins, Lapadula,
Arko. Drafting the article: Cohen, Evins. Critically revising the
article: Bernardo, Cohen, Evins. Reviewed submitted version
of manuscript: all authors. Approved the final version of the
manuscript on behalf of all authors: Bernardo. Administrative/
technical/material support: Evins. Study supervision: Bernardo,
Evins, Stieg.

Supplemental Information
Previous Presentations
Portions of this work were presented at the proceedings of the
27th Annual Meeting of the North American Skull Base Society

Correspondence
Antonio Bernardo, Weill Cornell Medical College, 525 East
68th St., Box 99, New York, NY 10065. email: anb2029@med.
cornell.edu.