# Surface Anatomy as a Guide to Vertebral Level for Thoracic Epidural Placement

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**BACKGROUND:** Precise placement of thoracic epidural catheters is required to optimize postoperative analgesia and minimize adverse effects. Previous research demonstrated that anesthesiologists are inaccurate when using surface anatomy to locate vertebral levels. In this study, we compared the accuracy of two different landmarks to identify the seventh thoracic (T7) spinous process.

**METHODS:** Two-hundred-ten patients referred for chest radiography were randomized to two groups. With patients in the anatomic (upright) position, one investigator identified and placed a radioopaque marker over the presumed T7 spinous process using either the vertebra prominens (C7) or the inferior scapular tip as a surface landmark. A radiologist, blinded to the identification technique, reported the spinous process corresponding to the radioopaque label. Marker positions were then compared using the Fisher's exact test. The influence of patient characteristics (age, gender, Body Mass Index [BMI], and height and weight) on accuracy was also examined.

**RESULTS:** Patient characteristics were similar between groups. The T7 spinous process was identified correctly 29% of the time with the C7 landmark and 10% of the time with the scapular landmark ($P < 0.001$). Accuracy improved for T7 $\pm$ 1 level to 78% and 42%, respectively ($P = 5.84 \times 10^{-8}$). Errors were more common in the caudal direction (i.e., T8 or T9 identified). The C7 landmark was more accurate among those with a BMI <25 ($P = 6.51 \times 10^{-5}$). In those with a BMI ≥25, both landmarking methods were frequently inaccurate ($P = 0.312$).

**CONCLUSIONS:** For patients with a BMI <25, the T7 spinous process can be reliably identified to within one interspace in 78% of patients using the C7 (vertebra prominens) surface landmark. Neither the vertebra prominens nor the tip of scapula is a reliable landmark to identify T7 in patients with a BMI ≥25.

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Optimal placement of thoracic epidurals improves the quality of analgesia while minimizing unwanted hemodynamic or motor side effects. Unnecessary dermatomal blockade may cause unwanted motor blockade, hypotension or both, particularly in the elderly.[1] Correct identification of the vertebral level serving the surgical site is the first step in providing optimal postoperative analgesia with minimal side effects. Previous research has indicated that surface anatomical landmarking is poor in identifying the lumbar interspace for lumbar epidural placement.[2–4]

Clinically, various surface anatomical landmarks are used to identify vertebral levels in the thoracic region. In one method, the vertebra prominens (C7) is identified and the spinous processes are palpated caudally. Alternatively, with patients placed in the anatomic position, a horizontal line drawn between the inferior tips of the scapulae corresponds to the seventh thoracic spinous process (T7). This study compared the clinical accuracy of these two different surface landmarks, C7 or the inferior scapular tip, in predicting the position of T7.

## METHODS

The Conjoint Health Research Ethics Board at the University of Calgary approved the study protocol. Adult patients presenting to the outpatient diagnostic imaging department for chest radiography were approached for enrollment in the study and informed consent was obtained. Exclusion criteria included patients with previous spine surgery or severe spinal anatomic abnormalities. To obtain 80% power to detect a 20% difference in accuracy between surface landmarks used ($\alpha$-level of 0.05), at least 97 subjects were required in each group. Subjects enrolled were

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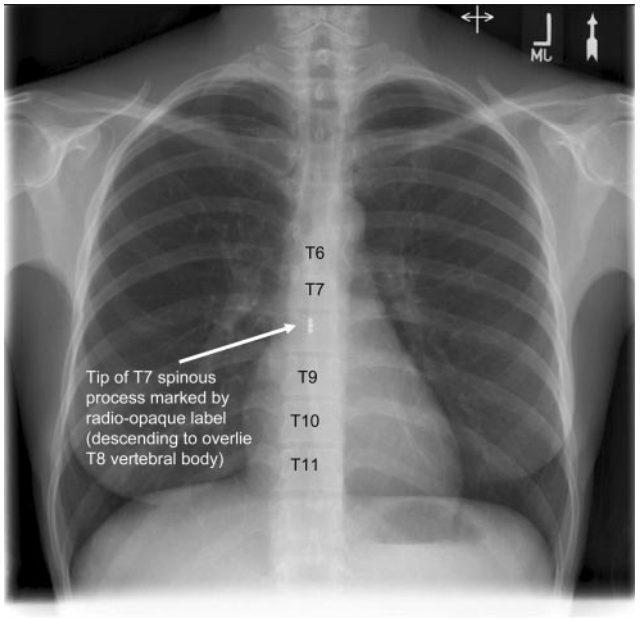


**Figure 1.** Chest radiograph with visible radio-opaque marker at T7 spinous process, vertebral bodies labeled numerically.

randomized via computer-generated random numbers into either the C7 or the scapular tip study group.

With patients in the classical anatomic position, a senior anesthesia resident attempted to identify the T7 spinous process using one of two surface landmarks (the vertebra prominens (C7) or the scapular tip) as reference points. After the vertebra prominens (defined as the most prominent cervical spinous process) was located, the investigator palpated inferiorly to reach the T7 spinous process. In the second group, the inferior tip of the scapula was palpated at 90° to the skin and the spinous process directly medial was located. Next, a radioopaque marker was affixed at the presumed level of the T7 spinous process, and routine posterior-anterior and lateral chest radiographs were obtained. A radiologist blinded to the landmarking technique used, interpreted each radiograph and reported on the radiologic level of the marker (Fig. 1). In ambiguous cases, a consensus of the appropriate spinous process was reached with two radiologists.

Blinded investigators then compiled the data and conducted the statistical analysis. The accuracy of each landmarking technique was calculated as the proportion of patients in which the clinical vertebral level corresponded to the radiographic vertebral level. The proportions of accurate assessments across techniques were then compared using the Fisher's exact test.[5] The impact of patient factors (age, gender, height, weight, and Body Mass Index [BMI]) on the accuracy of clinical landmarking was also examined.

## RESULTS

Two-hundred-ten patients were recruited for this study; 106 patients were randomized to the C7 group and 104 patients were randomized to the scapular group. Patient characteristics, including age, gender, height, weight and BMI, were equally distributed between landmarking groups (Table 1). Counting down from the C7 prominens accurately located the T7 spinous process in 29% of patients compared to the scapular landmark, which correctly identified T7 in only 10% of patients ($P < 0.001$) (Table 2). If attempting to identify T7 ± 1 level, the C7 spinous process was also more

**Table 1.** Characteristics of Patients Randomized to C7[a] or Scapular Landmarking Groups

| | Method of landmarking | |
|---|---|---|
| | C7 $n = 106$ | Scapular tip $n = 104$ |
| Age (years) | | |
| Range | 19–84 | 15–87 |
| Mean (SD) | 55 (18) | 51 (17) |
| Height (cm) | | |
| Range | 145–198 | 150–191 |
| Mean (SD) | 170 (10) | 171 (11) |
| Weight (kg) | | |
| Range | 47.0–131.0 | 39.9–136.1 |
| Mean (SD) | 77.0 (17.1) | 75.6 (16.8) |
| BMI[b] ($kg/m^2$) | | |
| Range | 16.8–40.7 | 15.5–42.9 |
| Mean (SD) | 26.4 (4.6) | 25.6 (4.7) |
| | *n* (%) | *n* (%) |
| Gender | | |
| Female | 49 (46) | 46 (44) |
| Male | 57 (54) | 58 (56) |
| BMI category | | |
| <25.0 | 43 (41) | 52 (50) |
| 25.0–29.9 | 39 (37) | 38 (37) |
| ≥30 | 24 (23) | 14 (13) |

[a] C7 = 7th cervical spinous process.

[b] BMI = Body Mass Index.

**Table 2.** Comparison of C7[a] to Scapular Tip for T7[b] Identification

| | Method of landmarking | |
|---|---|---|
| Radiologic level of marker | C7 ($n = 106$) *n* (%) | Scapular tip ($n = 104$) *n* (%) |
| Thoracic vertebra | | |
| T5 | 1 (1) | — |
| T6 | 10 (10) | 1 (1) |
| T7 | 31 (29) | 10 (10) |
| T8 | 42 (40) | 32 (31) |
| T9 | 19 (18) | 38 (37) |
| T10 | 3 (3) | 17 (16) |
| T11 | — | 6 (6) |
| Level* | | |
| Correct (T7) | 31 (29) | 10 (10) |
| Incorrect (all others) | 75 (71) | 94 (90) |
| Level* | | |
| Correct (T7) | 31 (29) | 10 (10) |
| Err by 1 level | 52 (49) | 33 (32) |
| Err by >1 level | 23 (22) | 61 (59) |

* The proportions of markers accurately located were compared across methods using Fisher's exact test. For accurate (yes vs. no), $P < 0.001$. For accurate (yes vs. wrong by 1 level vs. wrong by >1 level), $P < 0.001$.

[a] C7 = 7th cervical spinous process.

[b] T7 = 7th thoracic spinous process.

**Table 3.** Impact of BMI[a] on Accuracy of T7[b] Identification

| | BMI category and method of landmarking | | | |
|---|---|---|---|---|
| | BMI <25 | | BMI ≥25 | |
| | C7 ($n$ = 43) $n$ (%) | Scapular tip ($n$ = 52) $n$ (%) | C7 ($n$ = 63) $n$ (%) | Scapular tip ($n$ = 52) $n$ (%) |
| Accurate T7 identification | | | | |
| No | 24 (56) | 48 (92) | 51 (81) | 46 (88) |
| Yes | 19 (44) | 4 (8) | 12 (19) | 6 (12) |

BMI = body mass index.

T7 = 7th thoracic spinous process.

C7 = 7th cervical spinous process.

accurate than the scapular tip (78% versus 42%, respectively) ($P = 5.84 \times 10^{-8}$). Errors were more common in the caudal direction; for example, the T8 or T9 spinous process was identified instead.

Age, gender, and height did not affect the accuracy of either method in locating T7. In patients with a BMI <25, C7 landmarking was much more accurate (44%) than scapular tip landmarking (8%) ($P = 6.51 \times 10^{-5}$). However, among those with a BMI ≥25, accuracy was low regardless of the method used (19% and 12%, respectively) (Table 3) ($P = 0.312$).

## DISCUSSION

This study compared the accuracy of two different surface landmarks for locating the seventh thoracic spinous process (T7) and found the vertebra prominens (C7) to be a more accurate landmark than the tip of the scapula. However, the accuracy for correct identification of T7 was low regardless of the method used. C7 is a fixed spinous process which may relate to the improved accuracy with this landmark. Despite careful attempts to place patients in the anatomic position before landmarking, the mobility of the scapula may have contributed to its inaccuracy.

Findings from our study are consistent with previous research involving both the thoracic and lumbar vertebral regions. The intercristal line has been shown to coincide with the L4 spinous process or the L4-5 interspace in 78.6% of patients.[6] When using this landmark, anesthesiologists correctly identified a particular lumbar interspace only 29% of the time.[2] Similarly, a study comparing ultrasound and palpation for lumbar intervertebral level found only 30% accuracy.[3] In the thoracic region, Holmaas et al.[4] used magnetic resonance imaging to compare two anatomic landmarks and found a 43.9% accuracy when using the intercristal line, compared with 12.2% when using C7. This is in contrast to our study in which the C7 reference point was more accurate.

One limitation of this study is that a single researcher conducted all the landmarking tasks. Although this reduced interobserver variability, it may also have introduced a learning curve effect. An additional limitation is the potential lack of clinical correlation between vertebral level identification and subsequent epidural tip placement and analgesic efficacy. Finally, radiologic identification of vertebral level on chest radiograph has its own inherent error that will impact results.

Patient characteristics were analyzed to determine if they influenced accuracy. Although gender, age, and height did not impact accuracy, BMI adversely affected accuracy. Identification of landmarks in overweight and obese patients was inaccurate using both methods (19% for C7 and 12% for scapula). However, in patients with a BMI <25, accuracy was higher when landmarking with C7 (44%). Although excessive subcutaneous fat certainly impacts the ease of palpation of a bony landmark and adversely affects landmarking accuracy in the lumbar region,[2] in the thoracic region, the impact of BMI is less clear. Holmaas et al.[4] were not able to identify a significant relationship between BMI and accuracy; however, they did find a significant relationship between BMI and correct identification of the reference landmark.[4]

In conclusion, palpating caudally from C7 is the more reliable method for determining thoracic vertebral level and is successful in 78% of patients within one interspace. Furthermore, there is a tendency to predict T7 lower than determined radiologically. Finally, our study indicates that in overweight or obese individuals neither surface landmarking method is particularly accurate.

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