Ultrasonography for the Evaluation of the Anterior Neck and Hematoma Before and After Anterior Cervical Spine Surgery

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INTRODUCTION:

With more anterior cervical surgeries (ACS) being performed in outpatient settings, the evaluation of postoperative hematoma and soft tissue swelling are crucial. Magnetic resonance imaging is the most common imaging modality to evaluate these features following surgery but can be costly or unavailable. Ultrasonography (US) is a cheaper, mobile, and more widespread imaging modality that has shown efficacy in evaluating fluid collections and soft-tissue morphology. Our goal was to assess the reliability of ultrasonography as a method to evaluate hematoma volume and the surrounding structures of the neck before and after anterior cervical spine surgery. Secondarily, we hope to develop a range of baseline hematoma formation and soft-tissue morphologic changes following ACS.

METHODS:

This is an IRB-approved prospective study from a single-center. All patients scheduled to undergo 1-3 level anterior cervical discectomy fusion (ACDF) or cervical disc replacement (CDR) by 6 fellowship-trained spine surgeons with no postoperative drain placement were recruited. Preoperatively and on the morning after surgery (POD1), patients obtained a neck US and a lateral cervical radiograph. The neck US was evaluated by an orthopaedic resident and a radiology resident for the following parameters: dimensions and presence of hematoma, visualized vertebral bodies, dimensions of bilateral longus colli, and ability to visualize the esophagus and trachea. Plain radiographs were evaluated for retropharyngeal soft-tissue swelling at C2-C7. Additionally, a fellowship-trained radiology attending evaluated the postoperative neck US for presence of hematoma to serve as the 'gold standard.' Inter-rater reliability was calculated for all measurements.

RESULTS:

From 2019-2022, 45 patients were enrolled in this study. The mean age was 50.9 ± 10.9 years with 53.3% females. Nineteen patients underwent 1-level and 25 patients underwent 2-level procedures. One patient had a 2-level CDR with a single-level ACDF (Table 1). Thirteen (28.9%) hematomas were observed on US on POD1; none of which were clinically significant. There were significant differences in the thickness of the longus colli pre- and postoperatively. A range of normal baseline soft-tissue morphologic changes following ACS was also established (Table 2). The intraclass correlation coefficient (ICC) was 0.685 (good reliability) for visualization of a postoperative hematoma and 0.970 (excellent reliability) for measurement of the hematoma long axis. When the two primary evaluators were compared to an attending radiologist, the ICC reliability was 0.921 (excellent reliability) for visualization of a postoperative hematoma and 0.867 (good reliability) for measurement of the hematoma long axis. Mean measurements for the hematoma long and short axes of all three evaluators were compared and found to not be significantly different (Table 3).

DISCUSSION AND CONCLUSION:

After ACS without drain placement, nearly one third of patients developed a hematoma observed on US, though none developed airway compromise. The average hematoma size was 3.1 ± 1.2 cm x 0.8 ± 0.3 cm. Neck ultrasound appears to be an effective method to evaluate hematoma and soft-tissue structures in the neck, before and after ACS, even for a non-radiologist trainee. With good to excellent inter-observer reliability, ultrasound after anterior cervical surgery may be an additional tool to allow for a quick, bedside hematoma evaluation without the need for traveling to the radiology suite for advanced imaging or radiologist interpretation.

Table 1. Patient Demographics

N of subjects	45
Age (years)	50.9 ± 10.9
BMI (kg/m^2)	28.2 ± 7.5
Female Gender	24 (53.3%)
Race	
White	37 (82.2%)
Black	3 (6.7%)
American Indian	1 (2.2%)
Asian	1 (2.2%)
Other	2 (4.4%)
Declined	1 (2.2%)
Ethnicity	
Not hispanic	39 (86.7%)
Hispanic	4 (8.9%)
Declined	2 (4.4%)
Former Smoker	10 (22.2%)
Current Smoker	3 (6.7%)
CCI Age	0.9 ± 0.9
ASA Class	
I	2 (4.4%)
II	41 (91.1%)
III	2 (4.4%)

Statistics are summarized as mean ± SD. All categorical variables reported as N (%). BMI, Body Mass Index. CCI Age, Charlson Comorbidity Index Age Adjusted. ASA, American Society of Anesthesiologists.

Table 2. Ultrasound & Radiographic Measurements

	Pre-operative	Post-operative	*p*-value	Average Δ
Longus colli thickness, Left (mm)				
AP lateral	6.7 ± 1.7	8.1 ± 2	**<0.001**	1.3 ± 1.9
AP transverse	8.7 ± 2.5	9.7 ± 2.5	**0.002**	0.9 ± 2.5
Med-Lat transverse	12 ± 2.6	12.9 ± 2.3	**0.024**	1 ± 2.3
Longus colli thickness, Right (mm)				
AP lateral	6.6 ± 1.3	8.5 ± 1.9	**<0.001**	1.9 ± 2
AP transverse	8.5 ± 2.2	10.6 ± 6	**<0.001**	2.1 ± 6.4
Med-Lat transverse	12 ± 2.6	13.2 ± 2.2	**<0.001**	1.2 ± 2.1
Total number of visible vertebral bodies	4 ± 0.5	3.9 ± 0.7	0.448	0.1 ± 0.8
Individual visible vertebral bodies				
C2	1 (2.2%)	1 (2.2%)	1	--
C3	15 (33.3%)	14 (31.1%)	1	--
C4	38 (84.4%)	34 (75.6%)	0.388	--
C5	45 (100%)	45 (100%)	0	--
C6	41 (91.1%)	43 (95.6%)	0.5	--
C7	33 (73.3%)	32 (71.1%)	1	--
Trachea visibility				
Right-sided	44 (97.8%)	42 (93.3%)	0.625	--
Left-sided	38 (84.4%)	34/44 (75.6%)	0.581	--
Esophagus visibility				
Right-sided	42 (93.3%)	36 (80%)	0.07	--
Left-sided	42 (93.3%)	33/44 (73.3%)	**0.012**	--
Postoperative hematoma (N)	--	13 (28.9%)	--	--
Hematoma dimensions				
Long axis (mm)	--	30.8 ± 12	--	--
Short axis (mm)	--	7.9 ± 3.1	--	--
Hardware visibility	--	45 (100%)	--	--

Statistics are summarized as mean ± SD. All categorical variables reported as N(%). P-value is reported for paired tests between pre- and post-operative values. Bold values indicate statistical significance (p≤0.05).

Table 3. Hematoma Measurements

	Reviewer 1	Reviewer 2	Reviewer 3	*p*-value
Hematoma dimensions				
Long axis (mm)	32.8 ± 10.4	28 ± 11.1	33.1 ± 13.3	0.602
Short axis (mm)	9.8 ± 5.1	6 ± 4.3	10.8 ± 5.9	0.154

Statistics are summarized as mean ± SD. P-value is reported for one-way ANOVA between measurements. Bold values indicate statistical significance (p≤0.05).