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Original Research Article

Transverse Process of Atlas as a Surgical Landmark for Various Head and Neck Surgeries- A Computed Tomography Assisted Study

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ABSTRACT

Background: Head and neck are complex regions with vital structures compactly arranged, hence it is essential to define important structures with respect to a common externally palpable landmark, such as the transverse process of atlas. This will direct the surgeon towards appropriate structures and hence serves as an important surgical landmark for complicated head and neck surgeries.

Materials and methods: In this retrospective study, the Computed Tomography scans of neck region at the level of first cervical vertebra were studied. The distance between the center point of transverse process of atlas and important neurovascular structures were measured bilaterally and documented and statistically analyzed.

Results: The study was performed on 50 Computerized Tomographic films belonging to both sex groups. The mean distance of Internal Carotid Artery anteriorly from the tip of transverse process of atlas was 22.69 mm, posteriorly Occipital artery was 12.46 mm vertebral artery on an average 25.34 mm, styloid process posterosuperiorly was 17.18 mm and internal jugular vein was at 9.06 mm. The minimum distance of internal jugular vein di anterior to the transverse process was 1.49 mm. There was statistical significance in the distances of internal jugular vein, styloid process, and the vertebral artery on the left and right sides. There was a strong correlation between the structures bilaterally.

Conclusion: This study will help in providing appropriate topographical knowledge of structures in relation to a common landmark which serves as an easier method of surface marking and may alleviate the risks of intraoperative and postoperative complications.

KEY WORDS: Transverse process, Atlas, Surgical landmark, Internal carotid artery, Internal Jugular Vein.

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BACKGROUND

The deep upper lateral neck is a complex region and comprises several bony structures, including the occipital bone, the mastoid process, the petrous part of the temporal bone, the ascending ramus of the mandible, the temporomandibular joint, and the vertebral column. In this complex space, important neurovascular structures such as the internal carotid artery (ICA), the internal jugular vein (IJV), the spinal accessory nerve, the vertebral artery (VA), and the hypoglossal nerve all communicate with the cranial cavity. The area has gained importance and attracted attention from surgeons because of the increasing number of skull base surgeries and accidental injuries involving important neurovascular structures [1].

The transverse process of atlas (TPA) is a useful guide during head and neck surgery, lying a finger breadth or less anteroposterior and deep to the tip of the mastoid process; it can therefore be easily felt in the depression between the mastoid process and the angle of the jaw [2].

The IJV descends through the jugular foramen, which is located directly above the anterior surface of TPA. Depending on the position of the TPA and the jugular foramen, the TPA can kink the IJV wall, which may lead to a rise in intracranial venous pressure [3].

The IJV, ICA, and spinal accessory nerve all lie anterior to TPA, hence TPA is considered as a key landmark in identifying these structures during skull base surgeries, difficult radical neck dissection and supraomohyoid neck dissection [4].

Currently, there are few studies that examine the distance between structures and the transverse processes of the Atlas vertebra. However, Basma et al. conducted a cadaveric study to estimate the distance between the TPA and the posterior-lateral sigmoid sinus. The sigmoid sinus, lying just below the asterion, is a feasible surgical landmark [5].

Hence, the present study will help provide appropriate topographical knowledge of structures relative to a familiar, important landmark, which may serve as an easier method of surface marking and, on the other hand, may alleviate intra- and postoperative risks and complications.

MATERIALS AND METHODS

Study design*:* Analytical study with a retrospective method of data collection.

Inclusion and exclusion criteria: In this study we included normal (contrast/non-contrast) CT(Computed Tomography.) scans, axial and coronal sections, showing the region of cervical vertebra. All CT (non-contrast) scan films of patients with a history of trauma to head and neck region with possible damage to cervical vertebrae or soft tissue and CT scans of patients with suspected cervical spondylosis were excluded in view of possible distortion of anatomy.

Sample size: Based on a study by Sheen et al with a relative precision 5% and desired confidence level of 95%, the sample size was estimated to be e”34 subjects. We hence recruited 50 subjects for the study [1].

Methodology: The data of CT scans of head and neck region in the past 6 months stored as soft copy in the Radiology department of our institution was extracted. After excluding the cases as per exclusion criteria, systematic random sampling was employed, which gave us a final sample comprising of 50 subjects. The main study was preceded by a pilot study, the reason being estimation of feasibility of the study in terms of duration and timing. The position and magnitude vectors of the third part of vertebral artery (VA) occipital artery (OA), internal carotid artery (ICA), internal jugular vein (IJV) and styloid process (SP) in relation to the TPA were estimated bilaterally using DICOM software**. (Figure 1 and Figure 2)**

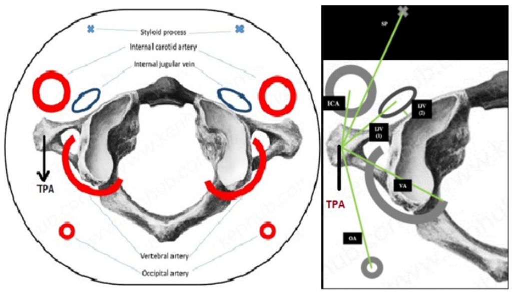

Fig. 1: Schematic Diagram Showing the Structures Measured from TPA)**.**

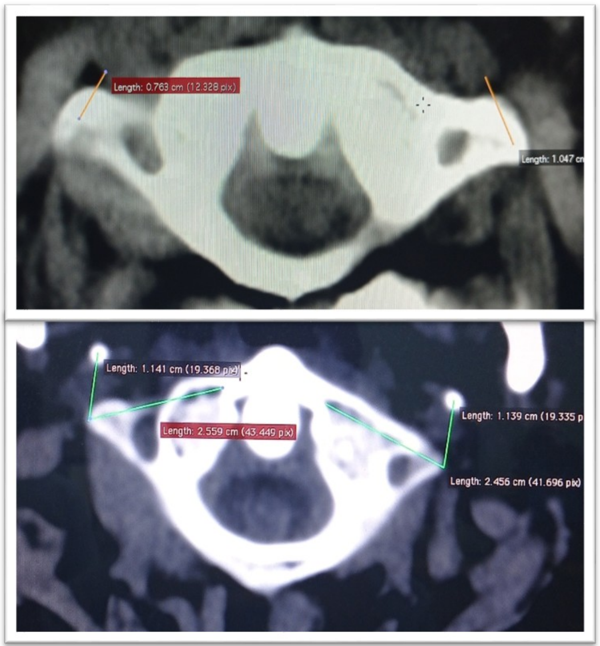

Fig. 2: Measurement of distance of various structures in CT scan).

Statistical analysis: Quantitative variables such as age, distance of structures from TPA are expressed in terms of mean & Standard deviation. Gender (categorical variable) was expressed as frequency and percentages. Differences in the mean values were tested for statistical significance by Student-t test. Statistical analysis was carried out using IBM SPSS version 22.0.

RESULTS

Among the 50 subjects, 20(40%) of them were males while 30(60%) were. females. The ages of the subjects ranged between 26 years to 49 years with a mean age of 44.30 years (SD= 13.81 years). While the mean age of male subjects was 45.75 years (SD= 18.7 years), average age of female subjects was 43.33 years (SD= 9.54 years). This data was comparable and showed no statistically significant difference.

Table 1: Descriptive statistics of distance of structure.

Distance between the midpoint of TPA and below mentioned structures	RIGHT			LEFT			TOTAL		
	Min (mm)	Max (mm)	Mean ± SD	Min (mm)	Max (mm)	Mean ± SD	Min (mm)	Max (mm)	Mean ± SD
ICA	18.53	28.26	22.93± 2.69	17.68	31.18	22.45±4.61	18.88	29.7	22.69±3.47
IJV	6.39	11.02	8.81± 1.61	5.26	18.6	9.3± 3.95	5.82	14.8	9.06± 2.65
IJV (shortest distance anterior to TPA)	1.47	1.95	1.71± 0.23	1.03	1.52	1.28± 0.23	1.25	1.74	1.49± 0.23
OA	1.36	22.23	12.32± 6.85	1.67	22.79	12.6± 7.01	1.63	22.5	12.46±6.9
VA	11.86	37.31	25.9± 7.92	12.06	32.41	24.79±6.81	12.14	34.9	25.34±7.29
SP	10.19	23.1	17.84± 3.38	9.71	20.62	16.51±3.44	9.95	20.8	17.18±3.16

Table 2: Comparison of distance of structures on right and left.

Structures measured in the study	Mean of difference	SD of difference	P value	Rho*
Internal carotid artery	0.48	2.96	0.283	0.797
Internal jugular vein (midpoint to midpoint)	0.48	2.88	0.266	0.78
internal jugular vein (shortest distance)	0.44	0.004	0	1
Occipital artery	0.28	1.38	0.178	0.98
vertebral artery	1.34	2.56	0.001	0.718
Styloid process	1.11	2.4	0.002	0.958

The mean distance of the internal carotid artery was 22.69 mm (SD=3.47). However, the mean distance was 22.93 mm (SD = 2.69) on the right side and 22.45mm (SD = 4.61) on the left side.

From the midpoint of C1 transverse process, the internal jugular vein was on an average at 9.06 mm (SD=2.65); 8.81 mm (SD=1.61) on the right side and 9.30 mm (SD = 3.95) on the left. However, the least distance directly posterior to the IJV was on average, 1.49 mm (SD=0.23); average of 1.71 (SD=0.23) on the right and 1.28 mm (SD= 0.23) on the left.

The occipital artery lies posteriorly on an average 12.46 mm (SD= 6.90) from the transverse process of C1 which varies from 12.32 mm (SD= 6.85) on the right side to 12.60 mm (SD= 7.01) on the left side.

The vertebral artery, on an average measures 25.34 mm (SD= 7.29) from the transverse process of C1 which varies from 25.90 mm (SD= 7.92) on the right side to 24.79 mm (SD= 6.81) on the left side.

The styloid process is located postero-superior to the transverse process of atlas at a mean distance of 17.18 mm (SD = 3.16) which varies on both sides; 17.84 mm (SD=3.38) on the right side to 16.51 mm (SD=3.44) on the left.

The differences in the distances of the structures on the left and right side were compared. The mean value of the differences ranged between 0.28 mm (occipital artery) to 1.34 mm (styloid process). The 'student t' test to test the level of significance was employed and there was a significance in the distances of internal jugular vein (shortest distance), styloid process and the vertebral artery on the left and right sides. In terms of correlation, there was a strong correlation however between all the structures bilaterally.

While head and neck region are comparably symmetric, there is a significant difference in the distances of the above-mentioned structures on both the sides. It can hence be inferred that the knowledge of the position and distance on one side cannot always be extrapolated to the contralateral side.

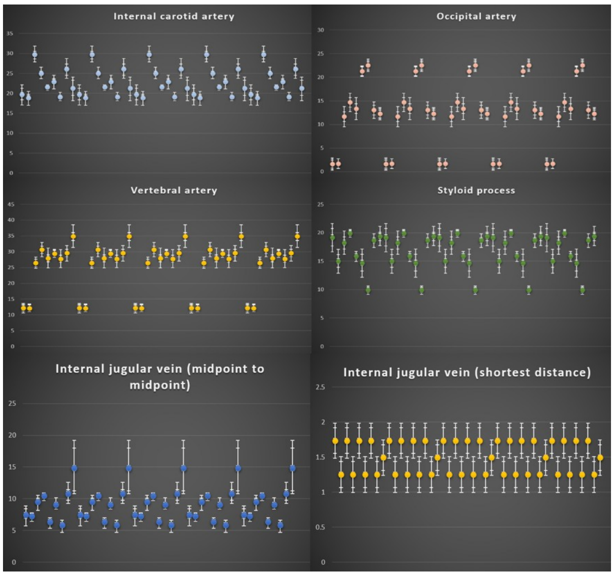

Fig. 3: Comparison of distances of structures bilaterally and average distance using error plot.

Figure 3 Graphically depicts the distances of various structures bilaterally among the subjects. The colored dot at the center of each plot depicts the average distance of the structure from the transverse process of Atlas. The difference in the distances of internal jugular vein on the right side and left side significantly differ, as shown in **figure 3.** Similarly, vertebral artery and styloid process showed a higher degree of difference when both sides were compared.

DISCUSSION

A study by Sheen et. al concluded that the internal carotid artery, internal jugular vein and spinal accessory nerves are the main structures preserved in conservative neck dissections. The transverse process of the atlas is an important surgical landmark in the upper neck with the neurovascular bundle located anteriorly [1].

Seoane et al., in 1999 investigated the cause of cerebellar hemorrhage following supratentorial craniotomy which came to interesting conclusions. In every specimen, the posterior wall of the internal jugular vein rested against the transverse process of the atlas as the vein descended immediately below the jugular foramen. In 38.9% of specimens, the transverse process indented the posterior wall of the vein, causing the vein to be slightly angulated as it descended across the anterior surface of the transverse process. Three veins were severely kinked as they descended [3]. This is further substantiated in our study with extreme proximity of IJV with the transverse process of atlas.

A cadaveric study was conducted by Sheen et al. It involved dissection via lateral cervical approach to assess the usefulness of the transverse process of the atlas as a reference guide. Here spatial relations with digastric muscle, stylohyoid muscle, the occipital artery have been studied along with internal jugular vein, cranial nerves X, XI and other structures entering and exiting the base of skull through various foramina [4].

Basma et al in 2021 conducted a cadaveric study with a similar approach. Underlining the importance of the topography of sigmoid sinus, its relation to an imaginary line joining the transverse process of atlas and the ipsilateral asterion was studied. The usefulness of this surgical landmark was elaborated in sigmoid sinus injury and in planning posterolateral skull base surgical procedures. since numerous procedures require neuro navigation technology, defining the structures in relation to the transverse process of atlas with the aid of 3D reconstruction of CT, would not only assist the surgeons, but retrospectively it can aid in increasing the precision of mapping and neuronavigational technologies.

The hybrid approach of cadaveric and radiological imaging served as stronger evidence to the study [5].

While performing the anterior approach to the cervical vertebral bodies, injury to important structures like the recurrent laryngeal nerve, external branch of the superior laryngeal nerve, sympathetic trunk and the spinal accessory nerve represents a serious risk. Awareness of the regional anatomy of these structures helps in identifying and preserving them while performing anterior cervical surgery or during exposure of the transverse foramen [6]. This serves as the counterpart of Atlas with respect to the other cervical vertebrae while essentially the results are comparable.

We do wish to undertake further studies that explore the usefulness of the said landmark for a much larger range of structures in not only 2D planes but also 3D.

Across the years, multiple researchers have investigated the usefulness of identifying the facial nerve using TPA as a bony landmark. Greyling et al [7] and Pather and Osamn [8] conducted cadaveric studies on the same, exploring the distance of facial trunk from various landmarks, bony and non-bony. The result of interest here is the mean distance from the TPA which was 16.9 mm (8.7–36.8) as per Pather and Osamn. Similarly, Greyling et al demonstrated that the mean distance from TPA to the facial trunk was 14.31 ±3.59 on the left side and 13.76 ± 4.65 on the right side [7].

Ji et al conducted a systematic review on the distance between facial nerve and various surgical landmarks, bony and non-bony, across over 10 studies including 357 subjects in total [9]. In this systematic review and meta-analysis of cadaveric studies, the mean distance of the facial trunk that was measured from structures namely tragal pointer, transverse process of atlas (TPA), posterior belly of digastric, mastoid process, tympanomastoid fissure, styloid process and external auditory meatus were analyzed. Overall, Ji et al concluded that there are substantial variations in the distance of trunk of facial nerve from a single landmark and hence it is imperative that surgeons take aid of multiple landmarks to locate the facial trunk and hence avoid complications. Among the structures from which the distances were measured, there was uniformity and lesser variance among TPA, mastoid process, tympanomastoid fissure and external auditory meatus.

Another important implication of our study comes with a variation of Eagles syndrome. Although typically, Eagle's syndrome can be associated with either mild obnoxious symptoms or severe sequelae such as cerebral ischemia/ transient ischemic attacks, another variant has been reported by multiple authors. The variant in discussion here is the extension of the styloid process towards or beyond the TPA which presents with more severe symptoms and is also referred to as the jugular variant of Eagle's syndrome [10-12]. Zamboni P et al investigated the variants of Eagles syndrome, with emphasis on the jugular variant. Some of the patients were presented with severe stabbing pain, odynophagia, dizziness and periorbital pain. Although these symptoms were not significantly different from the classic and carotid variants, numbness and headache were significantly higher in patients with the Jugular variant. The associated comorbidities namely perimesen-cephalic hemorrhage, multiple sclerosis and dilated ventricles CSF spaces were more common among patients with jugular variant and were statistically significant. This variant could also lead to compression of IJV and subsequent hemorrhage due to the same [10].

Most of the literature we have cited here are cadaveric studies in contrast to ours which was a radiological study. The implications of our study in terms of identification of structures, management of syndromes and sequelae along with mitigation of complications are to be focused on. We wish to further extend our research to cadaveric studies and intra-operative observational study.

CONCLUSION

One major strength of our study was being able to define multiple structures in the same axial plane. This, in turn, is theorized to direct the operating surgeon better rather than defining various structures in different planes.

With appropriate topographical knowledge of structures in relation to a common important landmark, on one side serves as an easier method of surface marking and on the other hand may alleviate the risks as well as intraoperative and postoperative complications.

Conflicts of Interests: None

ABBREVIATIONS

TPA: Transverse Process of Atlas
ICA: Internal Carotid Artery
IJV: Internal Jugular Vein
OA: Occipital artery
SP: Styloid Process
CT: Computerized Tomography
DICOM: Digital Imaging and Communications in Medicine
C1: First Cervical vertebra/ Atlas
VA: Vertebral Artery
CSF: Cerebrospinal Fluid
2D/3D: 2/3Dimensional

Author Contributions

Dr Madhu P Raj: Concept, Design, Literature Search, Data Analysis, Statistical Analysis, Manuscript Preparation, Manuscript Editing, Manuscript **Dr Jyothi Krishnarajanagar Chandrachari:** Literature Search, Data analysis, Statistical Analysis, Manuscript Preparation, Manuscript Editing, Manuscript Review and final approval. **Dr Anupama Kodailbail:** Statistical Analysis, Manuscript Preparation, Manuscript Editing, Manuscript Review. **Dr Radhika Paramesh Mudaliar:** Manuscript Preparation, Manuscript Editing, Manuscript Review. **Dr Eilene Basu:** Manuscript Editing, Manuscript Review. **Dr Shailaja Shetty:** Manuscript Editing, Manuscript Review.

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