The versatility of intraoperative ultrasound in spine surgery for intradural tumors

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The versatility of intraoperative ultrasound in spine surgery for intradural tumors

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ABSTRACT

Background: Ultrasound has been used as an intraoperative imaging option for spine surgery in 1982 and provides benefits as a great imaging modality for assessing soft tissue pathologies in real-time. Along with the development of technology and the presence of advanced imaging modalities, the role of ultrasound is often forgotten. In Indonesia, the role of intraoperative ultrasound has not become a routine modality for spinal tumor surgery despite its advantages and versatility. This study aimed to determine the role of intraoperative ultrasound for intradural spinal tumor surgery and to what extent the intraoperative ultrasound can be utilized based on our experience.

Methods: Two cases of intradural spinal tumors with different pathologies were presented. The initial diagnosis was made through contrast-enhanced magnetic resonance imaging scans. Intraoperative ultrasound was used to show the tumor in a sagittal fashion on three occasions, which were pre-removal, removal, and post-removal phase.

Results: We found intraoperative ultrasound to be a great and versatile modality in spine surgery, especially for intradural spinal tumors. This modality can be used for both total and hemilaminectomy and for both intra- and extramedullary pathology. Real-time evaluation can be performed quickly, radiation-free, cost-effective, and sensitive in assessing soft tissue.

Conclusion: Intraoperative ultrasound is a versatile modality for intradural spinal tumor surgery. The use of this modality needs to be introduced and taught in teaching programs and should become a routine modality for spinal tumor surgery, especially in developing countries where advanced intraoperative imaging modalities are not yet available.

Keywords: intraoperative ultrasound, spine surgery, spine tumor, ultrasonography.
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INTRODUCTION

Ultrasound is one of the imaging modalities that has been around for a long time. This modality is known for its practical, non-invasive use and is used in many health fields, one of them is neurosurgery. In 1982, ultrasound began to be used intraoperatively in cases of the spine by Dohrmann and Rubin. They used ultrasound after the laminectomy so that the previously obstructed view of the laminae was now able to show a clear view of the underlying structures. Intraoperative ultrasound is considered as a modality that can effectively display intradural lesions in real time.[1]

The author found some literature that says that intraoperative ultrasound can help the continuity of spine surgery, including in determining the location of tumors, and assisting surgeons in operating strategies to find out how much tumor has been removed—all done in real-time with tools that are non-invasive, relatively inexpensive and easily accessible.[2-8]

According to the World Bank, Indonesia is included in the classification of countries with lower-middle-income economies with population variations from various socioeconomic strata where advanced imaging modalities are not available or affordable.[9] This condition should increase the necessity to make intraoperative ultrasound with all its advantages as a modality of choice that is routinely performed in Indonesia. However, the fact remains that intraoperative ultrasound has not become a routine modality for spinal tumor surgery in Indonesia despite its advantages and versatility. This study aims to determine the role of intraoperative ultrasound for intradural spinal tumor surgery and to what extent intraoperative ultrasound can be utilized based on our experience. To the best author have known, this study was the first to discuss intraoperative ultrasound practice on spinal tumor surgery in Indonesia.

METHOD

Intraoperative ultrasound was performed using a BK Medical, bk5000 ultrasonography device (Fig. 1A) with their X18L5s (9009) Hockey Stick Transducer. This transducer has a contact surface of 9 x 32 mm with a frequency range of 18-5 MHz (Fig. 1B). We used a posterior approach in both cases. A midline skin incision was then made to expose the posterior spine followed by total or hemilaminectomy. After the dura mater is identified, the operating field is filled with normal saline (saline bath) as a conducting medium to reduce direct contact with the spinal cord. Then the transducer is placed along the axis of the spinal cord within the saline bath to obtain an image of the sagittal spinal cord (Fig. 2).

Intraoperative ultrasound was used to show the tumor in a sagittal fashion on three occasions, which include pre-removal, removal, and post-removal phase. Pre removal phase image serves

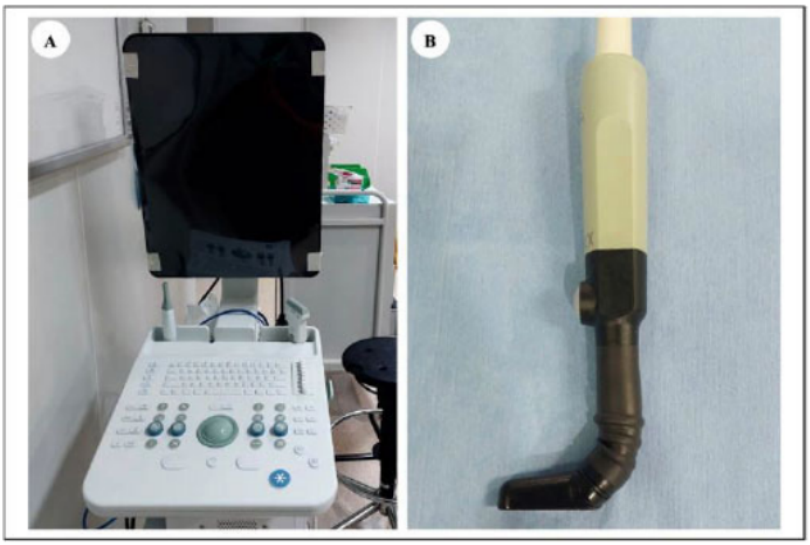

Figure 1. A. The ultrasonography device; B. The transducer.

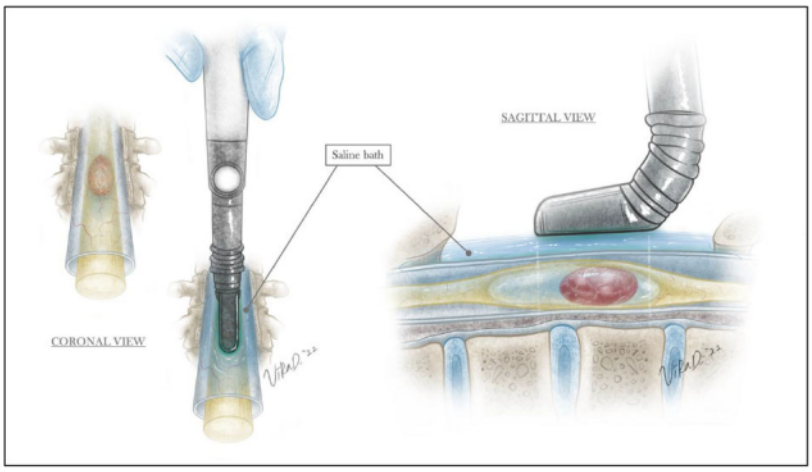

Figure 2. Intraoperative ultrasound was used to show the tumor in a sagittal fashion before the durotomy, right after the laminectomy. After the dura mater is identified, the operating field is filled with normal saline as a conducting medium and to reduce direct contact with the spinal cord. Then the transducer is placed along the axis of the spinal cord within the saline bath to obtain an image of the sagittal spinal cord.

as a baseline for comparison with other images obtained during surgery and as a guide in determining the location of the tumor. Removal phase image can be done as many times as needed by the surgeon to monitor the course of surgery thus making additional surgery plans when needed. Post removal phase image serves as an evaluation before closing.

We also used intraoperative monitoring (IOM) to record and evaluate motor evoked potential (MEP) and somatosensory evoked potential (SSEP) as long as necessary to minimize the risk of nerve injury.[3,10]

RESULTS

In this study, we presented two cases of intradural spinal tumor surgery, one case of an intramedullary tumor, and an intradural extramedullary tumor. We deliberately chose the intradural pathologies of the thoracic region, where anatomic landmarks tend to be more challenging to define than other regions. The initial diagnosis is made through contrast-enhanced magnetic resonance imaging (MRI) scans. The level of laminectomy was matched with the preoperative MRI scans, which were later confirmed by pre removal phase of intraoperative ultrasound. During the operation, we use intraoperative ultrasound and IOM regularly to monitor and evaluate the progress of the steps taken to ensure efficiency and safety.

Case 1

A 42-year-old male patient with back pain for the last two years with numbness from the thigh to both lower extremities. Clinical neurological examination revealed hypoesthesia from the L2 level below without autonomic disturbance. Preoperative MRI scan with contrast revealed an intramedullary lesion with mural nodule and cystic component, homogenous contrast enhancement of 1.3 x 0.9 x 3.4 cm at the level of T2-T3 (Fig. 3).

After the total laminectomy, the pre-removal phase of intraoperative ultrasound demonstrated the location of the lesion consistent with the MRI findings (Fig. 4). Circumferential dissection and piecemeal resection of the tumor were performed while looking at the SSEP and MEP results regularly. The histopathological examination was stated as ependymoma.

Case 2

A 56-year-old female patient with gradual bilateral lower extremities weakness since last year until both legs cannot be moved for the last seven months. There is numbness from the chest and below. Clinical neurological examination revealed paraplegia (bilateral lower extremity muscle strength of 0/5), and hypoesthesia from the T4 level below without autonomic disturbance. A preoperative MRI scan with contrast revealed an intradural extramedullary isointense lesion with well-demarcated, diffuse contrast enhancement of 1.3 x 0.9 x 2.1 cm within the left lateroposterior spinal canal posteriorly at the level of T1-T2, spinal cord driven to the right lateroanterior by the lesion (Fig. 5).

After the hemilaminectomy, the pre-removal phase of intraoperative ultrasound demonstrated the location of the lesion consistent with the MRI findings (Fig. 6). Tumor resection is done in a piecemeal fashion while looking at the SSEP and MEP results regularly. The histopathological examination was stated as schwannoma.

Figure 3. Case 1: Preoperative magnetic resonance imaging pf sagittal and axial T1W contrast-enhanced (A) and T2W (B), revealed an intramedullary lesion with mural nodule and cystic component, homogenous contrast enhancement of 1.3 x 0.9 x 3.4 cm at the level of T2-T3 which suggests ependymoma.

DISCUSSION

Intraoperative ultrasound has not yet become a modality that is routinely used for spine tumor surgery in Indonesia. The use of this modality has not been included in the residency learning program and does not yet have guidelines for its use. This is in line with a study by Harel and Knoller in 2015 that this modality does not yet have a learning program and procedural guidelines that can help improve the learning curve of surgeons.[10] Therefore, we try to divide the use of intraoperative ultrasound into three phases, namely pre-removal, removal, and post-removal phase. Each phase has a role and is expected to facilitate practitioners who are new to this modality.

Pre removal phase is carried out after the laminectomy, where the dura mater has been exposed and the operating field is filled with normal saline (saline bath). The images obtained in this phase serve as a baseline and determine the location of the tumor along with the transition zone in real-time. In the two cases presented, we did not perform any additional fluoroscopy because the image shown in this phase already showed structures beneath the dura mater with minimal opening access. We discovered that this modality can be used for both total and hemilaminectomy and for both intra- and extramedullary pathology. The transition zone between the tumor and surrounding normal tissue can be clearly seen at this phase (Fig. 4A and Fig. 6A). This phase can be used as a baseline for comparison with subsequent images throughout the surgery.

The removal phase can be done after confirming the location and transition

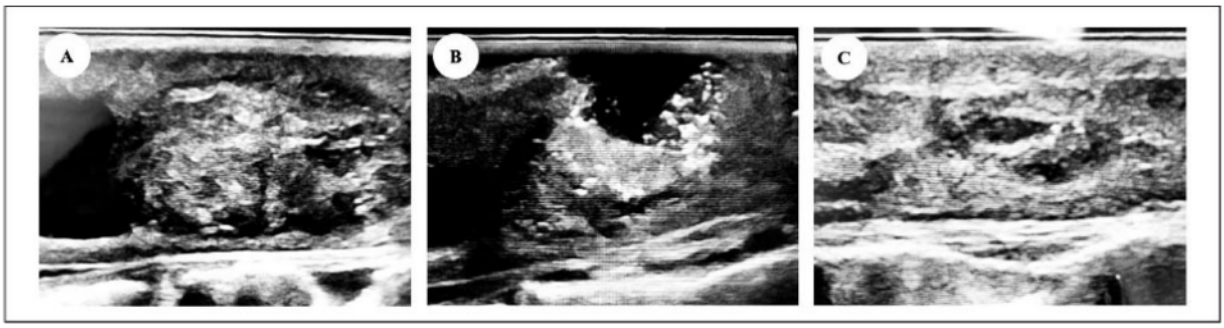

Figure 4. Case 1: Pre-removal (A), removal (B), and post-removal phase (C) intraoperative ultrasound images.

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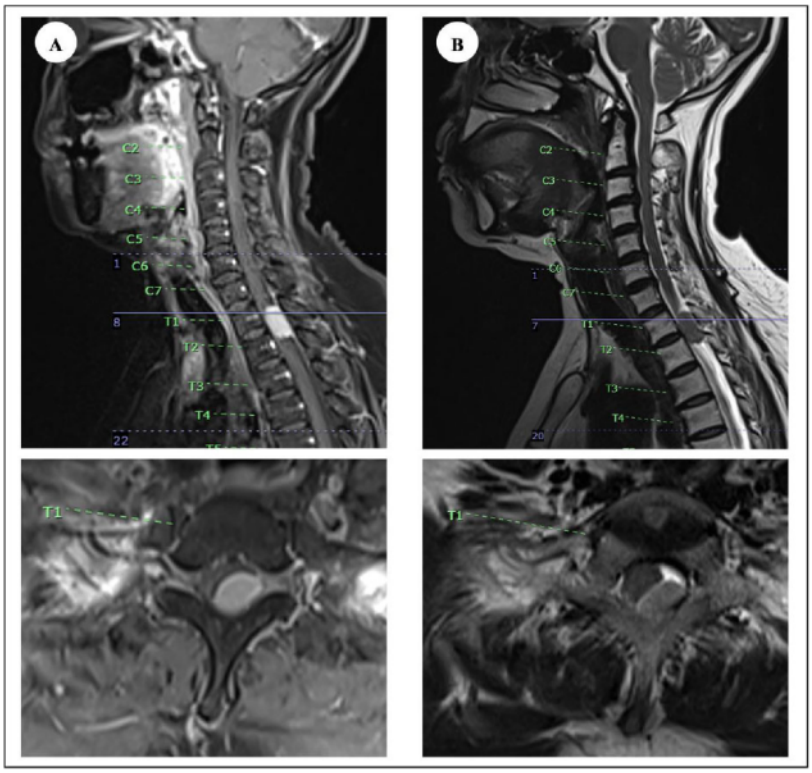

Figure 5. Case 2: Preoperative magnetic resonance imaging of sagittal and axial T1W contrast-enhanced (A) and T2W (B), revealed an intradural extramedullary isointense lesion with well-demarcated, diffuse contrast enhancement of 1.3 x 0.9 x 2.1 cm within the left lateroposterior spinal canal posteriorly at the level of T1-T2, spinal cord driven to the right lateroanterior by the lesion.

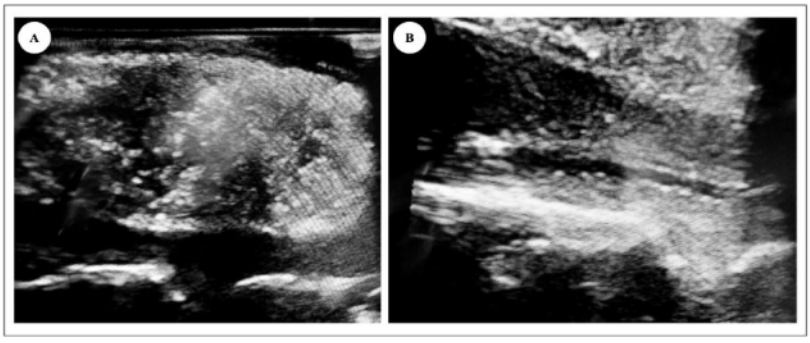

Figure 6. Case 2: Pre-removal (A) and post-removal phase (B) intraoperative ultrasound images.

zone of the tumor. This phase can be carried out continuously to monitor the progress of tumor resection. According to Saxena *et al* (2013) and Prada *et al* (2014), the combination of using intraoperative ultrasound with IOM can significantly reduce further neurological deficits from the tumor resection in spinal tumor removal procedures.[3,11] In our intramedullary case (Case 1), the tumor within the spinal cord needs a more delicate approach, this is where the role of this phase becomes crucial so that tumor resection can be done in piecemeal fashion while evaluation is done visually through intraoperative ultrasound and functionally through IOM.

Post removal phase is performed after the tumor resection before closing. We can compare the image obtained from the pre-removal phase with these in order to evaluate the results of the resection and detect residual tumors.

The majority of spinal tumors are non-malignant lesions, this makes total resection a goal while still prioritizing patient safety by working precisely, quickly, and efficiently. Intraoperative MRI (iMRI) can provide higher-resolution soft tissue imaging than intraoperative ultrasound, but this modality is time-consuming, expensive, and not widely available, especially in developing countries such as Indonesia.[1,3,9] This finding is in line with the current situation in daily practice when iMRI had not been used in our hospital which was known as one of the referral centers for neurosurgery cases in Indonesia.

On the contrary, the use of intraoperative ultrasound for spinal surgery is very possible in Indonesia. Ultrasound machines that have been routinely used are already capable and sophisticated enough that this versatile modality does not require enormous further investment. However, we do need to adjust the size of the probe and the footprint used, given the delicate structure of the spinal cord and the small operating field. The appropriate probe size for spine surgery should be 20 mm or smaller in diameter with a frequency ranging from 4 to 10 MHz.[12]

By reviewing our experience in using intraoperative ultrasound for intradural spinal tumor surgery, we found that this modality can be the first choice for evaluating the course of surgery in real-time, radiation-free, cost-effective, and sensitive in assessing soft tissue.

CONCLUSION

Intraoperative ultrasound is a versatile modality in intradural spinal tumor surgery. This modality can even become the surgeon's third eye to see the exact location of the underlying structures and detect residual tumors in real time without having to perform unnecessary additional procedures such as fluoroscopy, laminectomy, and durotomy. The

limitation of this study is that we only used an intraoperative study in the sagittal fashion, it would be better if the axial view was also included, especially for lesions that are anterior to the spinal cord. Given the versatility of this modality, intraoperative ultrasound should become a routine modality for spinal tumor surgery in developing countries such as Indonesia where advanced intraoperative imaging modalities are not yet available.

CONFLICT OF INTEREST

There is no conflict of interest.

FUNDING

No funding.

ETHICAL APPROVAL

We already obtained local ethical clearance approval.

AUTHOR CONTRIBUTIONS

Vira Dwi Nisrina: design, literature search, data analysis, manuscript preparation, manuscript editing and review. Yunus Kuntawi Aji: clinical study, definition of intellectual content, data acquisition, data analysis, manuscript preparation, manuscript editing and review. Muhammad Faris: manuscript editing and review. Fadhil: manuscript editing and review.

REFERENCES

1. Vasudeva VS, Abd-El-Barr M, Pompeu YA, Karhade A, Groff MW, Lu Y. Use of intraoperative ultrasound during spinal surgery. Global Spine Journal. 2017; 20:1-9.
2. Rustagi T, Das K, Chhabra HS. Revisiting the role of intraoperative ultrasound in spine surgery for extradural pathologies: Review and clinical usage. World Neurosurgery. 2022;164:118-127.
3. Prada F, Vetrano IG, Filippini A, et al. Intraoperative ultrasound in spinal tumor surgery. J Ultrasound. 2014;17:195-202.
4. Haciyakupoglu E, Yuvruk E, Onen MR, Naderi S. The use of intraoperative ultrasonography in intradural spinal tumor surgery. Turkish Neurosurgery. 2019;29(2): 237-241.
5. Velho V, Kharosekar HU, Bhople L, Domkundwar S. Intraoperative ultrasound an economical tool for neurosurgeons: A single-center experience. Asian Journal of Neurosurgery. 2020;15:983-988.
6. Knake JE, Chandler WF, McGillicuddy JE, et al. Intraoperative sonography of intraspinal tumors: Initial experience. American Journal of Neuroradiology. 1983;4:1199-1201.
7. Raghavendra BN, Epstein FJ, McCleary L. Intramedullary spinal cord tumors in children: Localization by intraoperative sonography. American Journal of Neuroradiology. 1984;5:395-397.
8. Ganau M, Syrmos N, Martin AR, Jiang F, Fehlings MG. Intraoperative ultrasound in spine surgery: History, current applications, future developments. Quantitative Imaging in Medicine and Surgery. 2018;8(3):261-267.
9. Simfukwe K, Iakimov I, Sufianov R, Borba L, Mastronardi L, Shumadalova A. Application of intraoperative ultrasound navigation in neurosurgery. Frontiers in Surgery. 2022;9:1-11.
10. Harel R, Knoller N. Intraoperative spine ultrasound: Application and benefits. Eur Spine J. 2015;25:865-869.
11. Saxena A, Rao G, Ivanov M. The value of intraoperative ultrasound in the recognition of pseudo-swelling of the spinal cord. Journal of Ultrasonography. 2014;14:89-93.
12. Moiyadi A, Shetty P. Objective assessment of utility of intraoperative ultrasound in resection of central nervous system tumors: A cost-effective tool for intraoperative navigation in neurosurgery. Journal of Neurosciences in Rural Practice. 2011;2:4-11

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