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Original Article

Surgery for metastatic epidural spinal cord compression in thoracic spine, anterior or posterior approach?

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ABSTRACT

Background: The most commonly encountered tumour of the spine is metastasis, and thoracic spine is the most commonly metastatic spine. Controversy exists regarding the optimal surgical approach for this kind of patient. The author conducted a study to assess the differences between anterior thoracotomy and a posterior approach in patients with malignant epidural cord compression in the thoracic spine.

Methods: Between January 2004 and December 2017, 97 patients with metastatic thoracic lesion were stratified into two groups by approach method to the lesion site: Group A - mean anterior thoracotomy, decompression and fixation; and Group P - represented posterior decompression and fixation. Survival time, neurologic status, each complication by surgery or in hospital, and days in intensive care unit(ICU) were compared.

Results: Twenty-five patients were grouped in Group A, and 72 patients belonged to Group P. Lung cancer was the most common primary cancer in both groups. Operation time (213.0 vs. 199.2 min, $p = 0.380$) and blood loss (912.5 vs. 834.4 ml, $p = 0.571$) were not statistically significantly different between the two groups. Six patients in Group A (24%) and 6 in Group P (8.3%) developed complications ($p = 0.040$). Patients in Group A required more days of care in ICUs (2.36 vs. 0.19 days, $p < 0.001$). The longer survival was seen in Group P (15.4 vs. 11.2 months) but with no significant difference.

Conclusion: A lower surgical complication rate and fewer days of care in ICU were seen in Group P. The authors would prefer a posterior approach for those with thoracic metastatic tumour.

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At a glance of commentary

Scientific background on the subject

Approximately 70% of metastatic spinal tumors are found in thoracic spine. The main goal of surgical treatment for metastatic spinal tumors is to reduce spinal cord compression and produce spinal stability. Most spinal metastatic tumors locate at anterior vertebrae and pedicles, and the optimal surgical approach remains controversial.

What this study adds to the field

Surgical approach to metastatic spinal tumors can be anterior method or by posterior way. We share our surgical experiences for metastatic spinal tumors in thoracic spine and found length of survival was similar in both approach methods, but a lower surgical complication rate was seen in posterior approach.

Metastatic tumours account for about 95% of all spinal tumours. This metastatic spine lesion can destroy the spine, result in loss of spinal stability, invade into the canal and compress the spinal cord, all of which cause pain and neurological impairment. Approximately 70% of metastatic spinal tumours are found in the thoracic spine, 20% in the lumbar spine, and 10% in the cervical spine [1]. The acute onset of metastatic epidural spinal cord compression (MESCC) usually requires immediate treatment. The role of surgery within the management of MESCC is not to cure metastatic tumours, but to reduce spinal cord compression and provide stability. Most spinal surgeons agree that direct decompression and tumour removal, followed by adequate fixation, can benefit patients with MESCC [2,3]. Many surgical methods have been proposed for MESCC. However, the optimal surgical approach remains controversial. Three decades ago, a surgical procedure with an anterior approach was developed for the treatment of MESCC. The benefits of this anterior approach for MESCC include the fact that tumours are often removed directly and reconstruction with a stable fixation is performed simultaneously. As most surgeons are conversant in a posterior approach with use of a pedicle screw system, an increasing number of articles in the last 20 years have mentioned the posterior approach to MESCC by indirect decompression, removal of the tumour mass through the pedicle, and fixation with posterior pedicle instrumentation [4,5]. With advancements of this technique, some surgeons have even been able to perform a total en bloc spondylectomy for MESCC [6,7]. As far as we know, there have been no studies comparing differences between anterior and posterior methods for MESCC with focus on complications, neurological status, and postoperative survival. In the present study, our patient database of thoracic metastatic spinal tumours for the past 15 years was examined to determine which surgical approach is the optimal method for patients with thoracic MESCC.

Methods

This study was approved by the Institutional Review Board of the Ethics Committee of Chang Gung Memorial Hospital (201900064B0). From January 2004 to December 2017, patients with metastatic tumours within the thoracic spine who underwent surgery in our department were reviewed retrospectively. All data were collected by accessing medical records. The inclusive criteria for the study were that patients must have suffered MESCC and received decompression, removal of the tumour mass, and fixation with instrumentation. We excluded those patients who received biopsy only, pure laminectomy only, vertebroplasty (VP)/kyphoplasty (KP) only, and minimally invasive surgery with percutaneous pedicle fixation combined with VP/KP without the decompression procedure. One-stage or two-stage combined anterior and posterior methods were also excluded. According to the approach to the lesion site, patients were divided into the anterior (A) and posterior (P) groups. In these patients, tumour masses were mainly localised within vertebrae with invasion into the pedicle and compression of the spinal cord. The surgical methods for each group were described briefly.

In Group A, the patients were put into a right or left lateral decubitus position consistent with their lesions being mainly on the right or left vertebrae. The incision was made directly over the rib; then, the rib was removed from the tip of the costal cartilage to the angle of the rib. The parietal pleura were incised and the chest cavity was opened as a result. The target vertebrae were identified and the tumour mass was removed to decompress the spinal cord. The vertebral space was reconstructed with polymethylmethacrylate (PMMA) cement, after which one-above and one-below segmental fixation was applied to the anterior spine. The wound was closed with a chest tube left inside the thoracic cavity. Fig. 1 shows a case from Group A.

Fig. 1 The image showed a case in the anterior group. Preoperative magnetic resonance imaging revealed a T11 metastatic lesion compression spinal cord (A). Anterior transthoracic approach, removal of tumor, and reconstruction with bone cement and screws were performed (B).

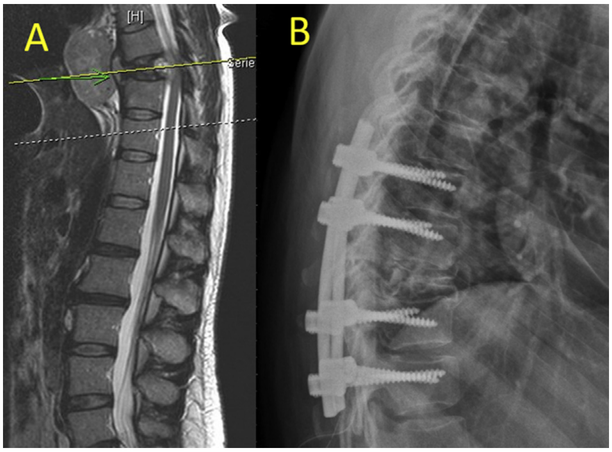

Fig. 2 The image showed a case in the posterior group. Preoperative magnetic resonance imaging revealed a T9 metastatic lesion compression spinal cord (A). Traditional posterior incision, laminectomy and posterolateral approach to decompress the tumor mass, and fixation by pedicle instrumentation (B).

In Group P, the patients were put into the prone position and a posterior midline incision was performed. Usually, two segments above and two below the most involved segment were exposed. A wide laminectomy with bilateral facetectomies of the involved segment should be performed. Then, the pedicles of the lesion segment were removed employing a rongeur or high-speed burr; the tumour mass was removed by curettage and a pituitary rongeur via the removed pedicle. Finally, the pedicle screw instrumentation was applied to the posterior spine and a non-suction drain was left in. Fig. 2 shows a case in Group P.

The revised Tokuhashi score [8] and the modified Bauer score [9] were used to record these patients' preoperative conditions. Data for both groups, including age, sex, operation time, blood loss during surgery, tumour level, origin of metastasis, stay in intensive care unit (ICU), and whether the patient received adjuvant radiotherapy or not, were recorded and compared. Patient outcomes were measured by survivorship, improvement in neurological status, and the development of complications. The duration of survival was considered to be the time between the date of operation and death, or the date of the latest follow-up if the patient is still alive. Neurological function was evaluated preoperatively and postoperatively (when they were discharged or transferred to the Oncology department); the neurologic status was assessed using the American Spinal Injury Association (ASIA) impairment score [10]: defined as being better or worse after surgery by a minimum of one degree on the ASIA scale. Any perioperative or postoperative complications were recorded and analysed in both groups, comparing the incidence of complications between the two groups.

Statistical analysis

The Chi-square test and Fisher's exact t test were used for categorical variables. The Mann–Whitney test was used for continuous variables. Kaplan–Meier curves were generated for survivorship in both cohorts; the log rank test was used to compare survival curves. A $p < 0.05$ was considered statistically significant.

Table 1 Demographic data in group A and group P.

	Anterior Group (N: 25)	Posterior Group (N: 72)	*p* value
Age	9.4 ± 10.7	62.3 ± 10.3	0.233
Sex (F/M)	12/13	33/39	0.852
OP Time (minutes)	213.0 ± 81.9	199.2 ± 61.8	0.380
Blood loss (c.c)	912.5 ± 834.1	834.4 ± 627.1	0.571
Tokuhashi Score	7.6 ± 3.2	8.4 ± 2.6	0.197
Bauer Score	1.76 ± 0.97	1.83 ± 0.98	0.747
RT (Y/N)	14/11	38/34	0.781
ICU stay (days)	2.36 ± 3.49	0.19 ± 0.70	<0.001
Complication (number)	6 (24%)	6 (8.3%)	0.040
Survival (months)	11.2 ± 11.9	15.4 ± 21.7	0.358

Abbreviations: N: number; F: female; M: male; Op: operation; RT: radiotherapy; Y: yes; N: no; ICU: intensive care unit.

Results

A total of 97 patients were enrolled after screening 121 patients: 25 were treated with thoracotomy, the removal of tumor mass, and fixation by bone cement and screw implant (Group A); the remaining 72 patients underwent posterior decompression, debulk of the tumour mass, and pedicle screw fixation (Group P). There were no statistically significant differences in gender or age between these two groups. Preoperative Tokuhashi scores were 7.6 ± 3.2 in Group A and 8.4 ± 2.6 in Group P ($p = 0.197$). The Bauer scores were also similar in both groups (Group A: 1.76 ± 0.97; Group P: 1.83 ± 0.98; $p = 0.747$). Group A had longer operating times (213.0 ± 81.9 min versus 199.2 ± 61.8 min; $p = 0.380$) and more blood loss (912.5 ± 834.1 ml versus

Table 2 Tumor Origin and Main involved Level.

	Group A (N: 25)	Posterior P (N: 72)
Tumor Origin		
Lung	8	16
Liver	4	4
Breast	2	9
Colon	3	9
Thyroid	1	3
Kidney	2	6
Prostate	1	10
Other	4	15
T spine level		
T1	1	0
T2	0	0
T3	0	4
T4	1	8
T5	3	7
T6	5	2
T7	3	5
T8	4	6
T9	6	6
T10	1	19
T11	1	10
T12	0	5

834.4 ± 627.1 ml; $p = 0.571$), but with no statistically significant difference. A total of 14 patients in Group A (56%) and 38 patients in Group P (53%) received combined radiotherapy. The patients in Group A usually needed to remain in the ICU longer, which was significantly different to those in Group P (2.36 ± 3.49 days versus 0.19 ± 0.70 days; $p < 0.001$). Basic demographic data between these two groups are outlined in Table 1.

Lung cancer was the most common primary tumour in both groups (8 in 25 for Group A and 16 in 72 for Group P). The most involved level of the vertebral body was from T5 to T9 in Group A. In contrast, the levels of vertebral body decompression were more normally distributed in Group P, with T10 and T11 being involved in most cases. Table 2 shows the primary tumour type and the main surgical vertebrae for both groups.

Complications

Six patients (24%) in Group A and 6 (8.3%) in Group P developed complications ($p = 0.040$). Each group had one patient who died within four weeks of the surgery by controlled sepsis. The main postoperative complications in Group A were pulmonary problems such as pneumonia or being ventilator-dependent. There was no wound infection in Group A, but wound-related complications were the most common problem in Group P: three patients needed surgery to debride the infected wound. Another major complication in Group P was haematoma formation. Three patients experienced post-operative neurological deterioration due to haematoma formation and needed further surgery to decompress the neurological tissue by removing the haematoma.

Neurologic status

Five patients in Group A and eleven patients in Group P were neurologically intact (ASIA E) preoperatively; the other 20 patients in Group A and 61 patients in Group P experienced a neurological deficit (ASIA D, C, B, or A) before surgery: specifically, around 45% of patients in both groups had not been able to walk (ASIA C, B, or A). The distribution of neurological status was similar in both groups ($p = 0.959$). One patient in Group A and two patients in Group P suffered neurologic deterioration immediately after surgery: massive haematoma formation was the most common reason, with 2 patients in Group P; the reason was unclear for the Group A patient but over-manipulation of the spinal cord during surgery or inadvertent injury to a spinal cord feeding vessel was suspected. Overall, all patients in both groups who were neurologically intact before surgery remained neurologically normal. Eight patients in Group A (32%) and 20 patients in Group P (27.8%) improved by a minimum of a single grade, while 15 patients in Group A (60%) and 43 patients in Group P group (59.7%) maintained an equivalent neurologic level, and two patients in Group A (8%) and nine patients in Group P (12.5%) worsened neurologically by a minimum of one degree on the ASIA scale. The postoperative neurological distribution in both groups was also similar ($p = 0.416$). According to the changes in neurological function before and after surgery, both the anterior and posterior approach methods had no statistically significant differences ($p = 0.800$). Table 3 represented data on neurologic changes in the two groups.

Table 3 Neurologic status in both groups.

	Group A (N: 25)	Group P (N: 72)	*p* value
Pre-operation ASIA			
A	1	4	
B	2	3	
C	8	27	0.959
D	9	27	
E	5	11	
Post-operation ASIA			
A	0	6	
B	4	5	
C	4	13	0.416
D	9	28	
E	8	20	
Post-operation versus Pre-operation			
I	8 (32%)	20 (27.8%)	
E	15 (60%)	43 (59.7%)	0.800
W	2 (8%)	9 (12.5%)	
Neurologic Deterioration Immediately after Surgery	1	2	0.761

Abbreviations: ASIA: American Spinal Cord Injury Association; I: improve; E: equal; W: worse.

Survival

In Group A, seven of the 25 patients survived for more than 1 year, but eight patients died within three months after operation. Survival rate was 68% at three months, 48% at six months, 28% at 1 year, and only 12% at 2 years. The mean survival time was 11.2 ± 11.9 months. In Group P, 27 of the 72 patients could survive for more than 1 year, but 27 patients still died within three months of surgery. The survival rate was 62.5% at three months, 52.8% at six months, 37.5% at 1 year, and 19.4% at 2 years. The mean survival time was 15.4 ± 21.7 months. The survival time was longer in Group P but there still was no statistically significant difference ($p = 0.358$). Fig. 3 shows the postoperative survival for both groups using Kaplan–Meier curves.

Discussion

The spine is the most common site of osseous metastasis. Spinal metastasis with pathological fracture and spinal cord involvement are two frequent complications that spinal surgeons are usually consulted on. The thoracic spine is often the site of these metastatic lesions, followed by the lumbar spine and cervical spine. Many options, including brace protection, steroid administration, external beam radiation, and surgery are advised for painful vertebral metastasis. The role of surgery in cases of spinal metastasis is not to cure cancer but to alleviate patients' symptoms. Patchell et al. performed a randomised, non-blinded trial with 51 patients receiving surgery followed by radiotherapy and another 50 patients receiving radiotherapy only for their spinal cord compression caused by metastatic cancer [11]. The results showed that surgery plus radiotherapy reduced the need for

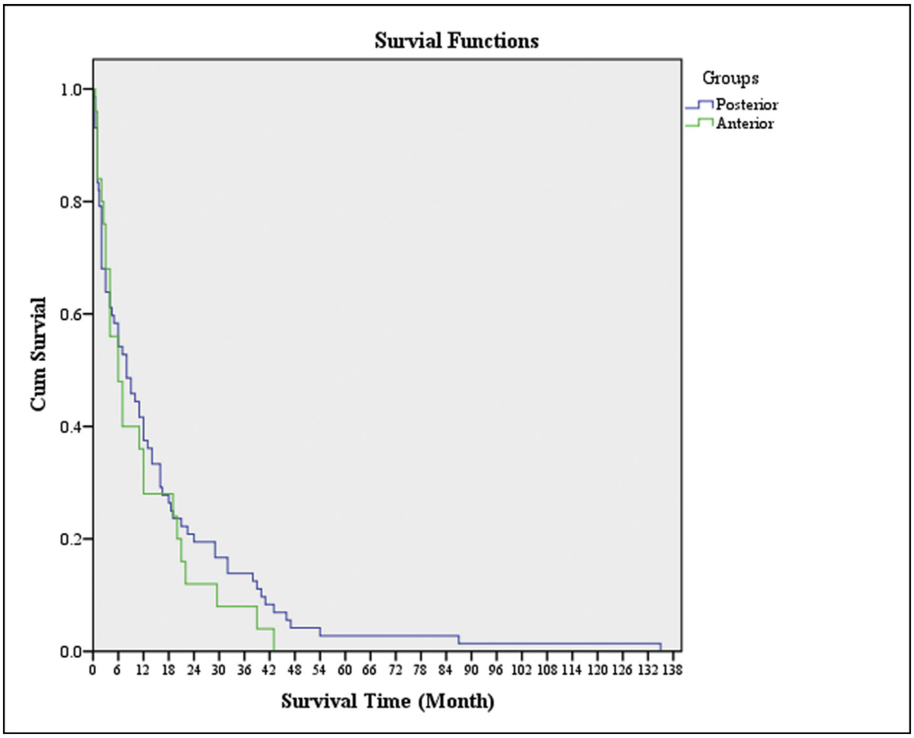

Fig. 3 Graph showing Kaplan–Meier survival curve for patients in both groups. The green line represented anterior group (mean survival time: 11.2 ± 11.9 months); the blue line represented posterior group (mean survival time: 15.4 ± 21.7 months). *p* value = 0.358.

corticosteroids and opioid analgesics, and significantly improved and maintained the ability to walk compared to radiotherapy alone, thus confirming the positive effect of surgery on patients with spinal metastasis lesions.

The ideal goals of surgery include confirmation of the primary diagnosis, decompression of neural elements, removal of the tumour mass to allow for a more effective adjuvant therapy, and spinal stability to allow mobilisation and prevent subsequent deformity. Many types of surgical approach have been advocated for treating spinal metastasis. Pure laminectomy was almost abandoned three decades ago because the stability of patients with metastatic lesions located at the vertebral body and pedicles is further reduced by removal of the posterior element. Constans et al. demonstrated that pure laminectomy had no benefit beyond radiotherapy in treating spinal metastasis [12]. The indication for pure laminectomy is very limited and usually for lesions over zone I and part of zone II according to the Weinstein classification [13,14]. With advancements in instrumentation and improvements in surgical techniques, many surgical methods have been developed to provide exposure for more radical tumour resection than pure laminectomy. Reconstruction and fixation can be performed after these aggressive procedures through anterior or posterior approaches such as anterior transcavitary, posterior transpedicular, or total en bloc spondylectomy. The anterior transcavitary approach to MESCC is very reasonable because most metastatic lesions are in the body and pedicles of the vertebrae. This anterior approach provides wide exposure to remove the tumour mass directly and allow reconstruction using PMMA with a fixation device. Compared to pure laminectomy, an anterior approach could significantly improve pain, function, and neurological status [15]. Chen et al. reported their experiences of 60 consecutive spinal metastasis patients undergoing anterior removal of the tumour and fixation with a cement and plate system; the results showed that 71% of patients (40 in 56) achieved pain relief over three months and 71% (33 in 42) had at least some degree of improvement in neurological function; however, the report did not provide their survival data after surgery [16]. Gokaslan et al. studied 72 patients with spinal metastatic tumours who were treated with anterior transthoracic vertebectomy; the data revealed that the 30-day mortality rate was 3% and the 1-year survival rate was 62% [17]. In our study, the average survival time was 11.2 months and the 1-year survival rate was 40% (10 in 25) in the anterior group. The survival time in patients with MESCC was not only influenced by the surgical method but also by the origin of the primary tumour, the patients' general condition, receiving adjuvant therapy or not, etc. We believe that the higher rate of lung cancer in the current study explains the lower survivorship compared to that found by Gokaslan et al. The complication rate with open thoracotomy for MESCC was around 30%, and our data were similar to those of the previous literature. Huang et al. claimed that surgical complications for thoracic MESCC could be reduced to 13% (4 in 29) using their minimal invasive method, which is better than using the traditional thoracotomy approach to MESCC [18].

After developing the posterior pedicle fixation system, an increasing number of surgeons have tried to use laminectomy followed by posterior instrumentation for MESCC, which became popular because a posterior approach is familiar to most spinal surgeons. With improvements in surgical techniques, a posterolateral approach to vertebrae has been developed to provide exposure for more radical tumour resection, and some surgeons have even developed a total en bloc spondylectomy for MESCC. Bilsky et al. reported their experiences of 25 cases undergoing a posterolateral transpedicular approach with circumferential fusion for MESCC; the results showed that 23 patients reported a significant improvement of pain and neurological status, with only one patient's neurologic function becoming worse immediately after surgery [19]. Wang et al. reported the largest case series containing 140 patients undergoing a single-stage posterolateral transpedicular approach with circumferential reconstruction for MESCC [20]. The results showed that operative complications occurred in 20 patients (14.3%), with wound complications in 16 patients being the main aetiology of total complications; the overall median survival time was 7.7 months. The overall complication rate in Group P of the current study was 14%, which is similar to that found by Wang et al. Although wound infection was also the main aetiology of complications in Group P of the present study, the incidence (4 patients, 5.6%) was lower than that in Wang et al.; Wang et al.'s procedure was longer (5.1 h versus 3.3 h) and there was greater blood loss (1500 ml versus 880 ml), which may have led to the higher incidence of wound complications. Furthermore, the average survival time in Group P of the current study was 15.4 months, which was different to that of Wang et al. This phenomenon can be explained by the survival time in MESCC being influenced not only by the surgery but also by type of tumour origin, general condition of the patient, multiple metastasis or not, response to radiotherapy/chemotherapy, etc.

The development of total en bloc spondylectomy seemed to be a resolution for MESCC. The intent of this surgery is en bloc resection of the tumour with negative histological margins. The procedure is highly demanding technically and has a high risk of neurological injury [21]. Although the results of this technique have been encouraging in some studies of MESCC [22], most surgeons believe that total en bloc spondylectomy should be reserved for those patients where surgery is being reserved as a curative means rather than palliative. Therefore, controversy remains among spinal surgeons over the role of total en bloc spondylectomy for MESCC patients.

In the current study, the results demonstrated that the anterior approach and posterior approach for MESCC seemed to be equivalent in terms of neurological function, postoperative complications, and survivorship. However, there were still some subtle differences between these two approaches. First, a higher percentage of patients in Group P showed neurologic deterioration because there were four patients in Group P had postoperative haematoma formation, which led to worse neurological function finally. Second, the total complication rate was higher in Group A (24% versus 14%) although without statistically significant differences, most complications in the anterior group were associated to poor pulmonary problems, which resulted in a longer ICU stay in the anterior group.

Minimally invasive techniques for spinal surgeries have obtained huge attention in the past 10 years. VP or KP have already approved their efficacy for the treatment of painful spinal metastasis without neurological deficit [23,24]. For those MESCC with neurologic deficit, a certain degree of decompression surgery is necessary. Therefore, minimal decompression followed by percutaneous fixation was advised for MESCC [25]. Compared to standard open surgery for spinal metastasis, minimally invasive spine surgery did not obtain more benefits in terms of neurological recovery and complications, but could show a significant improvement in terms of blood loss, operation time, and duration of bed rest [26].

The incidences of postoperative symptomatic spinal epidural haematoma formation after posterior spinal procedures range from 0.16% to 0.42% [27,28]. Surgery for metastatic tumours in the spinal column is thought to be a risk factor for developing postoperative epidural haematoma [29]. In the current study, a 1/8 inch drain was used for the posterior group; when there was excessive bleeding or a clot in the drain, it was easy to identify the surgical site haematoma formation and compress the spinal cord. In contrast, the size of the chest drain for anterior surgery in the current study was usually 28 Fr (28/3 mm); this was large enough for drainage of postoperative bleeding from the chest cavity, so there was no symptomatic haematoma formation from anterior surgery.

Indeed, this article still has some limitations. First, the type of primary tumor might influence morbidity no matter how the surgical resection is, which might lead to bias in analysis of morbidity in each group. Second, length of survival time can also be influenced by the heterogeneous origin of cancer, the primary tumor should be controlled as possible to prevent bias in the future's study. Third, most cases in Group A located at T5 to T9 but cases in Group P were distributed evenly from mid-thoracic to lower thoracic level, which might influence surgeon's decisions to choose approach method for the metastatic lesions. Fourth, operations were not performed by the same surgeon, which could interfere with final surgical outcomes because the experience or abilities of the different surgeons were different. Furthermore, this study enrolled 97 patients, which seems to be a lot, but the number of patients in the two groups was somewhat different (25 vs. 72). The power analysis of various variables was around 0.6 (not shown in Result Part), and the statistically significant power was weakened.

Conclusions

Patients in Group P required significantly less time in the ICU than patients in Group A. Furthermore, a lower surgical complication rate was seen in Group P. Based on the results of this study, the author preferred the posterior approach by transpedicular decompression and fixation for those with thoracic metastatic tumours and epidural compression. However, a prospective confirmatory study is warranted due to the nature of this retrospective study.

Conflicts of interest

The authors declare that there no conflicts of interest regarding the publication of this paper.

Ethics approval and consent to participate

This study was approval by the Institutional Review Board of the Ethics Committee of our institute (number: 201900064B0).

Data availability

The data used to support the finding of this study are available from the corresponding author upon request.

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