Editorial

Percutaneous vertebral augmentation—pearls and pitfalls

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Comment on: Nogami R, Matsuoka H, Ohashi S, *et al.* Spinal subarachnoid hemorrhage after percutaneous kyphoplasty: a case report and literature review. J Spine Surg 2022;8:491-6.

Keywords: Percutaneous vertebral augmentation procedure; kyphoplasty; vertebroplasty; subarachnoid hemorrhage

Submitted Nov 28, 2022. Accepted for publication Jan 03, 2023. Published online Feb 07, 2023.
doi: 10.21037/jss-22-106
View this article at: https://dx.doi.org/10.21037/jss-22-106

Percutaneous vertebral augmentation (PVA) procedures, such as vertebroplasty and kyphoplasty, are commonly utilized surgical approaches mainly indicated for treatment of osteoporotic vertebral fractures, multiple myeloma and osteolytic metastatic lesions. First described by Galibert *et al.* in 1987 (1), continued evolution of techniques and materials has resulted in a notable improvement in terms of safety and effectiveness (2,3). However, the first two randomized controlled trials published in 2019 comparing vertebroplasty with a sham procedure showed no differences in terms of pain and quality of life at one week or at one, three, or six months after treatment, with only a trend towards a higher rate of clinically improvement in pain in the vertebroplasty group (4,5). Based on this, guidelines initially did not recommend the use of vertebroplasty and kyphoplasty as an option for the management of painful osteoporotic compression fractures (6). However, since then, many more randomized controlled trials have been published, with all but one reporting the superiority of vertebral augmentation compared with optimal medical management in terms of pain scores and quality of life (7-12).

The mechanism of pain relief associated with PVA has not been fully elucidated. It appears that restoration of the vertebral height is a crucial step for maintenance of the sagittal balance, thus decreasing the efforts generated by the paraspinal muscles (13,14). Moreover, restoration of vertebral rigidity and load-bearing capacity is thought to reduce painful micromotion (15,16).

In terms of surgical technique, PVA is usually a safe procedure, with pitfalls that can be avoided with a strict observation of several principles and, most importantly, careful patient selection. PVA is strongly indicated in patients describing a focal, intense, deep pain in the midline of the spine. This pain should be mechanical, meaning worse while standing and better with recumbency (17). Magnetic resonance imaging (MRI) of the spine is useful to identify the acute and subacute fractures that usually respond well to PVA. Acute fractures demonstrate edema as decreased T1 and increased T2 or short-inversion-time inversion recovery (STIR) sequence signals (18). MRI may also differentiate osteoporotic fractures from pathologic fractures that result from metastasis or infection.

A number of concerns regarding PVA should be mentioned. First of all, the risk of cement extravasation is higher in patients with cortical disruption or preexisting radicular complaints; these cases should be treated with alternative procedures (19). PVA are also technically

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challenging in cases of vertebra plana, loss of more than 66% of vertebral height or fractured bodies inferior to the pedicle (20). During the procedure, several important steps should be adhered to. First of all, true lateral and antero-posterior views should be obtained and images should be frequently checked to have a real-time and constant control of the trajectory. Care should be taken not to pierce the anterior cortex of the vertebra to reduce the risk of extravasation. Furthermore, cement should be of adequate consistency before it is injected to minimize the risk of leak through the fissures or into the venous sinuses.

A recent study by Nogami et al. (21) , which is published in *Journal of Spine Surgery* describe a case of T12 and L1 percutaneous kyphoplasty for osteoporotic vertebral fracture, complicated by post-operative loss of sensation and strength in the lower extremities. Imaging demonstrated an intradural hematoma and a fracture line in the medial cortex of the right pedicle at T12. Emergency decompression was performed with good clinical recovery. The important experience of Nogami *et al.* highlights one of the critical points of the PVA procedure which is the insertion of the Jamshidi needle into the pedicle. This step is often more challenging when approaching small pedicles, such as those found in the thoracic vertebrae. It is important to avoid medial direction which can fracture the pedicle causing cement extravasation and neurovascular injury.

The study also highlights the potential role of CT-based or robot-assisted navigation with the purpose of preventing complications. Zhang *et al.* (22), in a recent meta-analysis and review, state that robot-assisted percutaneous vertebral augmentation (RA-PVA) is more accurate in determining the ideal needle entry-point, leading to increased safety and lower rates cement leakage. Furthermore, fluoroscopy-assisted percutaneous vertebral augmentation (FA-PVA) may require more fluoroscopy time and multiple punctures, possibly determining further damage to the fragile vertebral body, thus increasing the chance of procedure failure.

Another important aspect assessed in this study is the length of surgery which seemed to be similar in both type of procedures. Being robot-assisted navigation a new technological tool, it could be possible to hypothesize that surgeons will become more confident with time, with shorten of the length of surgery compared to FA-PVA. Interestingly, clinical outcome reported using VAS (Visual Analog Score) and ODI (Oswestry Disability Index) had similar results (23).

In conclusion, although prospective data establishing the merits of PVA over nonoperative treatment are still lacking, PVA has proved to be a safe and effective procedure that should be recommended only in patient with specific clinical and radiological features. Aside the risk of procedure failure in terms of pain control, the most inconvenient scenario is represented by procedural complications. The most common of whose is the cement extravasation. Indeed, robot-assisted percutaneous vertebral augmentation is a potentially interesting and useful tool that could improve safety and outcomes. Further data and studies need be conducted to assess its real effectiveness, evaluating benefit-cost balance.

Moreover, it is important to underline the fact that surgeon's role remains essential for the success of the procedure, regardless the technology and the technique used. Indications, unexpected intraoperative findings, and anatomical variants cannot be examined by any robot or navigation system, and the surgeon remains the main responsible to guide each case toward the success. The case report and literature review by Nogami *et al.* serve as an important reminder on maintaining safe principles during procedures such as percutaneous kyphoplasty.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the editorial office, *Journal of Spine Surgery*. The article did not undergo external peer review.

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jss.amegroups.com/article/view/10.21037/jss-22-106/coif). RJS reports research grant from Northern Ontario Academic Medicine Association and speaker's honorarium from Pfizer Canada, Bayer Canada, and HLS Pharmaceutical. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Cite this article as: Espahbodinea S, Ku JC, Costa Alves Junior A, Singh RJ, Deshmukh AS, Chavda V, Priola SM. Percutaneous vertebral augmentation—pearls and pitfalls. J Spine Surg 2023;9(1):13-16. doi: 10.21037/jss-22-106