Combined cone beam computed tomography and fluoroscopy techniques for challenging percutaneous spine procedures

Transpedicular approaches for spine procedures are currently employed in biopsies and vertebroplasties (VT), and frequently performed with computed tomography (CT) or fluoroscopy for image guidance. The fluoroscopy is not always reliable in terms of visualization if the pedicle is very small or destroyed by osteolytic lesions. CT is more precise in these situations but needle progression is not visualized in dynamic view. We describe 3 cases where the anatomic landmarks were not well visualized in normal fluoroscopy and transpedicular needle implantation was achieved with a combined C-arm cone beam CT acquisition (CBCT), known as XperCT, and fluoroscopic overlay guidance, namely XperGuide.

Keywords: transpedicular approach; fluoroscopy, computed tomography (CT); XperCT, XperGuide.

INTRODUCTION

Transpedicular approaches for spine procedures are currently employed in biopsies and vertebroplasties (VT), and frequently performed with computed tomography (CT) or fluoroscopy for image guidance. Considering that the pedicle might be small (e.g. high thoracic levels) or severe affected in tumoral lesions, the fluoroscopy is not always reliable in terms of visualization. CT can give more anatomical information despite these situations; however the dynamic needle progression is missed. CT gantry limits the access of the operating field; it is not always possible to get images in the needle axe depending on this obliquity. Another CT disadvantage is the necessity to repeat an acquisition after each needle repositioning and consequent radiation rate.

In this article, we will describe 3 recent cases where the anatomic landmarks were changed by tumoral destruction and needle advancement was achieved with a combined C-arm cone beam CT acquisition (CBCT), known as XperCT, and fluoroscopic overlay guidance, namely XperGuide.
Material and Methods

After evaluation through a multidisciplinary board including neuro-interventionist, oncologist and neurosurgeons, 3 consecutive patients were recruited. The decision to place the needle by percutaneous approach with XperGuide assistance was made by the neuro-interventionist and was based on pre-operative imaging data showing difficulties to proceed without image guidance.

Patient 1

48-year-old woman treated, since 2001, for plasmocytoma of the eleventh thoracic vertebra (D11). At this time, the patient was submitted to a surgical treatment with D11 partial corporectomy (right side) and instrumentation from tenth (D10) to twelfth thoracic vertebra (D12). Recent follow-up showed local tumor re-growth with laboratorial exams not clearly correlated to a plasmocytoma recurrence (fig. 1). The oncologist responsible for the patient asked for a biopsy in order to obtain accurate diagnostic.

Patient 2

Male 61-year-old patient with pulmonary adenocarcinoma detected 1 year ago and immediately metastatic (bone and liver). The patient developed important thoracic pain and a general screening showed a second thoracic vertebra (D2) fracture probably secondary to a metastatic process. MRI confirmed the metastatic nature of this lesion, posterior wall infraction and epidural extension (fig. 2). Radiotherapy did not provide enough pain relief. VT was indicated for analgesic control and stabilization of the fracture.

Patient 3

Male 69-year-old patient with important dorsal pain and simple spine radiography showed a pulmonary tumor and fracture of the fourth thoracic vertebra (D4) 2 month ago. Complete investigation confirmed a multi-metastatic pulmonary adenocarcinoma with fracture of D4, posterior wall infraction and epidural extension (fig. 3). Radiotherapy was performed without enough pain relief. VT was indicated for pain control and vertebral stabilization.
Before intervention, the coagulation status was reviewed and prophylactic antibiotherapy was administrated. Each patient was treated under general anesthesia to reduce as much as possible the risk of movements.

All 3 patients were in prone position. Interventions were performed in the angio-suite equipped with a biplane flat panel (Philips Allura Xper FD20, Best, The Netherlands) offering XperGuide facilities.

For patient 1, anatomic landmarks were difficult to identify because of the metallic surgical material and the poor bone density (fig. 4). Patients 2 and 3 had also osteolytic lesions and poor pedicle visualization (fig. 5).

A 2.4 x 100 needle was used for all procedures. For patient 1, after transpedicular approach, a biopsy sheath (1.83 x 150mm) was inserted and progressed up to obtain bone samples (fig. 6). The needle was partially removed in order to change the direction. An inferior orientation was achieved using dynamic fluoroscopy and we obtained more bone samples (fig. 7). No cement injection was performed.
Planification

We first performed a pre-procedural CBCT to localize the lesion and to provide the data for XperGuide planification functionality. This CBCT consists in a high dose XperCT of 620 rotational images around 240° was used for all patients in order to get the best image quality. The needle planning was performed on CBCT volume data with Xtravision workstation (Philips, Best, The Netherlands). Optimal pathway of the needle trajectory was planned from skin (entry point) to the target avoiding sensible structures as spinal cord (fig. 8).

Navigation

XperGuide software is able to calculate automatically the exact position of the C-arm in 2 main positions: entry point and progress view. Entry point view is the direction tangent to the needle trajectory and is consequently displayed as a single point (overlaying of entry point and target—“bull’s eye view”). From entry point view axis, 90° projection provides the progress view. The XperGuide guidance consists in hybrid images made of an overlay of CBCT data, live fluoroscopic images and planned path as shown in figure 9. CBCT and path overlay does not provide any real time data for the navigation. The first centimeters needle progression were visualized in entry point view in order to control the double obliquity of the needle. Further needle progression was achieved along the planned trajectory in progress view until reaching the target. Since the progress view provides information on needle deviation in only one plane, we regularly switch to entry point view during needle progression to control possible deviations in other plane. It should be noted that despite using XperGuide to place the needle, usual fluoroscopy is still available during whole procedure for double checking.

**RESULTS**

Target was successfully reached in all cases. The biopsy performed to patient 1 was appropriate to the histopathologic analysis. The cement injection was also successfully performed to patients 2 and 3 with a satisfactory radiologic result (fig. 10).

No complication was detected. All 3 patients did not develop neurological impairment after procedure. Patients 2 and 3 presented important pain relief on the same day of the intervention.
Most percutaneous transpedicular approaches for spine procedures can be performed under fluoroscopy; bone landmarks are correctly visualized and the needle placement is considered safe and accurate. The main advantages of fluoroscopy are dynamic progression of the needle, control of cement injection in 2 views2,6,8 and lower radiation doses if compared to CT 5. For osteolytic lesions or severe osteoporosis, anatomic landmarks are not well visualized and the risk of complications will be higher. Biafora et al. described a hemorrhagic complication by injuring the fourth lumbar artery during transpedicular approach; the entry point and transpedicular trajectory were far lateral and the needle probably damaged the artery1. On the other hand, needle positioning far medial can originate epidural hematoma and secondarily bring about epidural cement leakage with severe consequences4,7. Some radiologists prefer CT guidance for difficult cases. Pedicles and soft tissues are better visualized and the needle placement will be safer. Some CT scanners offer fluoroscopy option for dynamic visualization, but only in 1 view (axial) or with few degrees of gantry angulations5.

XperGuide presents some advantages when compared to static CT guided procedures. The first one is the possibility to follow needle progression on fluoroscopy with the planned path and the CBCT overlay to adapt the trajectory during the procedure, as we performed for patient 1. The slight change allowed during the progression is normally in superior and inferior orientation. Lateral and medial changes must be avoided because of the risk to go into the spine canal. Concerning vertebroplasty, the main advantage of XperGuide is the possibility to switch immediately to standard fluoroscopy and proceed with cement injection that is better with dynamic control and 2 views (anterior-posterior and lateral views)3. The main technique limitation is necessity of prone position and general anesthesia that is not appropriate for all oncologic patients. The discussion with the oncologist must be attempted before procedure considering the procedural risk without guidance system or contra-indications of general anesthesia. We strongly recommend against performing XperGuide with local anesthesia and sedation for spine procedures. Leschka et al. consider that error margin is inferior to 5 mm in patients under general anesthesia and involuntary movements add more important millimeters that can bring about lack of precision6.

Compared to fluoroscopy procedures, XperGuide requires more time to install the patient. Prone position, general anesthesia and suitable patient positioning is mandatory to permit C-arm rotation. Arms can be installed throughout the body depending on patient configuration. Obese patients are almost impossible to be correctly installed on angio-table for this technique6.

Despite percutaneous transpedicular approach for spine procedures is a very well known technique with relatively few complications, few millimeters are enough to have serious consequences. Therefore experienced operators must take technique evolutions that provide a safer procedure into consideration.
CONCLUSION

Percutaneous transpedicular approach to spine procedures requires anatomic landmarks visualization to be considered safe. Considering that severe complications might follow incorrect needle placement, XperGuide represents an alternative for risky cases where general anesthesia and ventral decubitus are acceptable.

REFERENCES


COMMENTS

Percutaneous spine procedures, such as biopsies and augmentation procedures, may be difficult to perform either because anatomical aspects (cervicothoracic junction for example) or pathological shuntings (pedicule destruction etc). CT-guided procedures are useful, but for augmentation procedures (either vertebroplasty or kyphoplasty) a real time image is needed in order to avoid intraoperative complications. Narata et al. show how they deal with these situations using a system that combines CT images data with real time fluoroscopic images. The great advantage seems to be to have both images in the same room. With this technical variation, classical procedures can be done more safely in some difficult cases.

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