Original Article

Diagnostic yield and technical aspects of fluoroscopy-guided percutaneous transpedicular biopsy of the spine: A single-center retrospective analysis of outcomes and review of the literature

ABSTRACT

Background: The technique of a percutaneous transpedicular biopsy of spinal lesions has been shown to be a useful alternative to paraspinal biopsy for vertebral body lesions in the thoracic and lumbosacral spine. Percutaneous vertebral biopsy is less invasive, cost-effective, and is suitable for patients with intractable back pain and vertebral body lesions that are detected with noninvasive imaging modalities.

Objective: The purpose of this study was to establish the diagnostic utility and spectrum of fluoroscopy-guided percutaneous transpedicular biopsies of the thoracolumbar spine performed at our institution.

Materials and Methods: This retrospective descriptive study to establish the diagnostic utility and spectrum of percutaneous fluroscopic guided transpedicular biopsy of lower thoracic and lumbar vertebral lesions has been performed on 42 patients in a tertiary care hospital between April 2017 and December 2019. There were 28 male patients and 14 female patients. The mean age was 48 years (range: 12–66 years). There were one 14 thoracic, 26 lumbar, and 2 sacral biopsy specimens. The lesion level was determined under fluoroscopy. Biopsy was taken with a trephine needle under local anesthesia. Accuracy and effectiveness of the technique were analyzed on histopathologic confirmation.

Results: The fluoroscopic guided percutaneous transpedicular spine biopsies of 42 patients with spinal pathology were performed through the posterior transpedicular approach percutaneously. Of the 42 patients, 28 were male (66.7%) and 14 were female (33.3%). Vertebral involvement was observed to be more in the lower thoracic region (26.2%), followed by the upper dorsal region (7.1%), L1 (23.6%), L2 (6.4%), L3 (14.6%), L5 (17.3%), and sacrum (4.8%). There were 21 cases with tumor etiology (14 metastasis, 2 malignant round cell tumor, 2 multiple myeloma, and 3 lymphomas), 14 tuberculosis (TB), 4 osteomyelitis, 2 inflammatory, and 1 isolated compression fractures. Twelve patients of the 14 diagnosed cases who were diagnosed with TB on histopathology had positive TB culture and sensitivity pattern.

Conclusion: Percutaneous transpedicular fluoroscopy-guided biopsy with a Jamshidi trocar with an internal diameter of 3.1 mm is a simple, safe, and reliable method for the etiological diagnosis of vertebral lesions. The use of this technique, however, is dependent on the accurate placement of the trocar and on close qualified interdisciplinary clinical cooperation. This minimally invasive technique is simple, safe, and effective in the diagnosis of malignant and infective lesions.

Keywords: Fluoroscopic, percutaneous transpedicular, spinal biopsy

INTRODUCTION

The potential complications of a paraspinal needle biopsy technique have been well-documented.[1] The more common ones are nerve root injury, pneumothorax, and troublesome hematoma formation.[2] This technique is also associated with a high incidence of false-negative results, especially in cases

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with the thick sclerotic bone not uncommon in osteoblastic tumors.[3] The technique of a percutaneous transpedicular biopsy of spinal lesions has been shown to be a useful alternative to paraspinal biopsy for vertebral body lesions in the thoracic and lumbosacral spine.[4] The presence of a spinal lesion raises many questions and with accompanying neurodeficit, it becomes an urgency. Clinicoradiological analysis helps in the diagnosis of these conditions; however in many cases, it is prudent to know the exact histopathology or microbiological diagnosis for proper management. Furthermore, in cases of infection (especially tuberculosis [TB]), drug sensitivity is essential for management. Early stages of spondylodiscitis may be difficult to differentiate from degenerative Modic 1 changes, inflammatory lesions (seronegative spondyloarthropathy), amyloidosis, or crystal deposition disease on magnetic resonance imaging (MRI), and scintigraphy.[5] Hence, biopsy may be required to make a distinction among these conditions. Furthermore, abnormal foci of marrow replacement within the vertebral column that are detected with noninvasive imaging modalities, such as computed tomography (CT) or MRI, also are often referred for spine biopsy. Spine biopsy is often performed to evaluate destructive or space-occupying lesions within the spinal axis. Various methods for vertebral biopsy have been described. With time, biopsy techniques have evolved from open biopsy to image-guided targeted biopsy techniques. Conventionally, open biopsy has been the gold standard for musculoskeletal lesions, providing adequate material; however, in vertebral lesions, performing an open biopsy can be a difficult procedure, which has a significant risk of complications. Percutaneous biopsy of the spine can be performed under various image-guided modalities such as fluoroscopy, CT, ultrasonography, and MRI.[6] The minimally invasive approach reduces recovery time and patient morbidity. Percutaneous transpedicular biopsy of the spine under fluoroscopy guidance is faster and cost-effective method of performing a biopsy. Unlike CT-guided biopsy, it does not require a big setup and can be done when only fluoroscopic C-arm is available. Fluoroscopic guided biopsy has less radiation exposure (compared to CT guided biopsy). More than 50% of the vertebral body tissues are accessible through this approach.[7] Thus, the transpedicular biopsy is a safe, economical, and clinically useful procedure in the diagnosis of spinal pathology with or without neurological involvement. The results of the biopsy will affect the subsequent clinical management of the patient and influence treatment decisions in such areas as surgery, chemotherapy, radiation therapy, and antibiotic therapy.

Objective

The purpose of this study was to establish the diagnostic utility and spectrum of fluoroscopy-guided percutaneous transpedicular biopsies of the thoracolumbar spine performed at our institution.

MATERIALS AND METHODS

This retrospective descriptive study to establish the diagnostic utility and spectrum of percutaneous fluroscopic guided transpedicular biopsy of lower thoracic and lumbar vertebral lesions has been performed on 42 patients in a tertiary care hospital between April 2017 and December 2019. There were 28 male patients and 14 female patients. The mean age was 48 years (range: 12–66 years). There were one 14 thoracic, 26 lumbar, and 2 sacral biopsy specimens. All were done under fluoroscopic. All the imaging studies (X-rays, MRI, and CT scan) were scrutinized and the level of biopsy was predetermined. Patients' informed consent was obtained prior to the procedure, and in case of children, guardians consent was obtained. Two specimens were obtained with the patient under general anesthesia, while 40 specimens were obtained with the patient under local anesthesia. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Ethics Committee (IEC), and informed consent was obtained from all patients prior to their enrollment in this study (IEC Approval Reference Number: 12/2017; IEC Approval Date: June 7, 2017).

Procedure of percutaneous transpedicular biopsy of the spine

The procedure was done under Local anesthesia except in children and anxious patients where general anesthesia was preferred.

Procedural steps

The percutaneous transpedicular biopsy was performed in the prone position on the fluoroscopy table. In planning the needle route, vital anatomical structures such as major blood vessels, nerves, peritoneal cavity, and spinal canal and its contents were avoided. In the thoracic spine, care was taken to avoid the pleural cavity, thoracic aorta, and superior vena cava. In the lumbar spine, the abdominal aorta, inferior vena cava, renal vessels, nerve roots, and organs, such as the kidneys, should not be punctured. The lesion depth, entry point, and angle of the chosen needle route were estimated preprocedure. The level of biopsy was decided on the basis of the previous plain radiographs, MRI, and CT scan images. Painting with povidone-iodine and draping of the region to be biopsied was done. Once the level was decided, anteroposterior (AP) and lateral views were taken on fluoroscopy, and the level of the biopsy was marked with the needle. In AP images, the spinous process should be in the midline of the vertebral body, equally placed between both the pedicles. The superior and inferior end plates should be

parallel, and the pedicles should be appropriately located at the caudal end of the ascending articular process. On the lateral view, the superior end plate should appear as one line and the pedicles should overlap and thus appear as one. All the aseptic precautions were followed before performing the percutaneous transpedicular biopsy. Local anesthesia (1 ml 0.1% lidocaine) was administered at the entrance point. A 0.5 cm incision was then made with a No. 15 blade 3–4 cm lateral to the midline. Subsequently, 10 ml bupivacaine was injected with an intravenous cannula needle up to the pedicle. Lumbar vertebrae were approached 5–7 cm laterally from the spinous process and with a vertical inclination of 60°. By changing the direction of the needle in a cephalad or caudal direction, tissue from two adjacent vertebrae and the intervertebral disk could be obtained. Thoracic vertebrae were approached 4–5 cm laterally from the spinous process with a vertical inclination of 30°–40° over the superior border of the respective transverse process to the vertebral body. A right-sided approach routinely was used unless the lesion was located on the left side [Figures 1-4].

A Jamshidi needle, which has a trocar, cannula, obturator, and a lock, was used to perform the biopsy. Jamshidi needle (8-gauge), which has a core cut of 3 mm, was used for the biopsy. The needle was passed through the soft tissues up to the pedicle. AP and lateral views were taken and the level of the biopsy was confirmed. The lateral view gives a good view of the anterior trajectory. In AP view, tip of the needle should be either in the center or lateral to it. Special care was taken not to damage the inferior and medial wall of the pedicle. This is to prevent any damage to the spinal cord by entering into the canal or damaging the nerve root. The trocar is locked in the cannula and entry into the pedicle was made with a gentle tap by a mallet and the needle was then passed into the pedicle while taking serial AP and lateral fluoroscopic images. The trocar was removed once it was 0.5 cm away from the lesion, and then, the cannula was advanced with a screwing motion to perform the core biopsy. The material for culture was withdrawn by means of aspiration. Finally, the cannula containing the core biopsy sample was withdrawn with a slight rotation. To extract the specimen, a negative pressure was applied to the trephine with a 20-cc disposable syringe, and the specimen was expelled using the obturator. While advancing the needle, the patient was asked if he had any of the sensory or motor weakness, and then, the needle was advanced and the required sample was collected. All the materials obtained were sent for culture, sensitivity, and histopathological examination (HPE). For histologic evaluation, core biopsy samples were fixed in formalin solution; biopsy material was collected in sterile dry tubes. The average duration of procedure was 25–30 min. After the biopsy, the puncture site was looked for any signs of hemorrhage or hematoma formation. Single stitch was taken at entry point incision and was cleaned with spirit and dressing was given.

Complications if any were managed accordingly. Strict bed rest was maintained throughout the recovery period. The patient was observed in recovery for 2–4 h, depending on the type of anesthesia that was used. Monitoring of the patient, including vital signs, was continued during the recovery period. When the patient was judged to be stable, either by the surgeon who performed the procedure or by the anesthesiologist who anesthetized the patient, he or she is discharged from the recovery area: an outpatient goes home and an inpatient to a hospital room.

Statistical analysis

This was an observational study and no comparative control arm was present. Descriptive statistics were reported using numbers and percentages to represent the data. Findings were tabulated using Microsoft Excel 2010 Microsoft Corp., Redmond, WA, USA, and statistical analyses were conducted using Statistical Package for the Social Sciences (version 20.0), IBM SPSS Statistics for Windows, V.20.0, IBM Corp., Armonk, New York, USA.

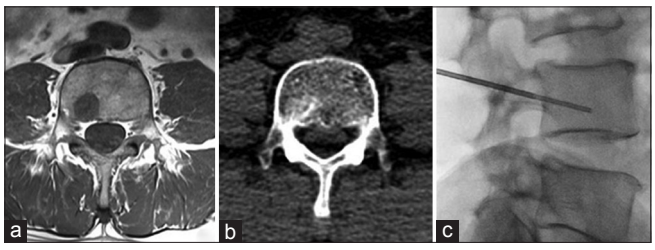

Figure 1: Fluoroscopy-guided vertebral biopsy in a 63-year-old male with lung adenocarcinoma. T1-weighted axial magnetic resonance image of a 2-cm hypointense mass in L4 vertebral body (a). Axial computed tomography scan of sclerotic lesion in the corresponding area of the L4 vertebral body (b). Percutaneous biopsy performed with a right transpedicular approach under fluoroscopic guidance (c). Biopsy confirmed the diagnosis of metastasis from lung cancer

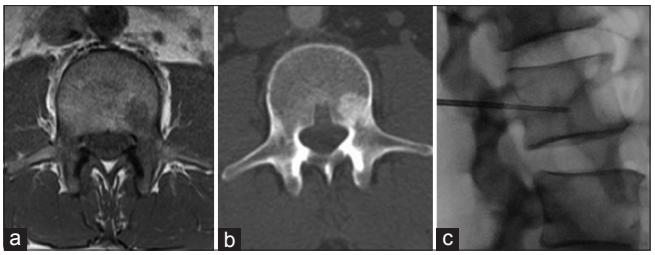

Figure 2: Fluoroscopy-guided vertebral biopsy in a 55-year-old male with pancreatic ductal adenocarcinoma. T1-weighted axial magnetic resonance image of a 1.8-cm hypointense mass in L3 vertebral body (a). Axial computed tomography scan of sclerotic lesion in the corresponding area of the L3 vertebral body (b). Percutaneous biopsy performed with a left transpedicular approach under fluoroscopic guidance (c)

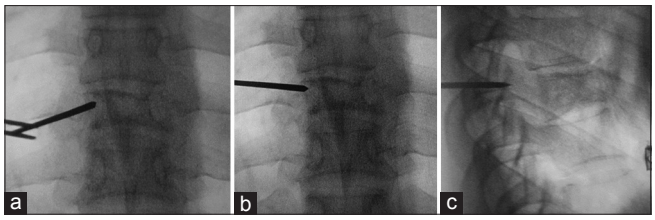

Figure 3: Entry point at the superolateral edge of the pedicle in anteroposterior views (a and b) and confirmation of cephalocaudal trajectory of the biopsy needle on lateral view (c)

RESULTS

The fluoroscopic guided percutaneous transpedicular spine biopsies of 42 patients with spinal pathology were performed through posterior transpedicular approach percutaneously. Of the 42 patients, 28 were male (66.7%) and 14 were female (33.3%). Only two biopsies were performed under general anesthesia on a 12-year-old male patient with a paraspinal swelling and dorsal spine involvement and 14-year-old female patient who was very apprehensive about the procedure. The rest of all the biopsies were performed under local anesthesia. Vertebral involvement was observed to be more in the lower thoracic region (26.2%), followed by the upper dorsal region (7.1%), L1 (23.6%), L2 (6.4%), L3 (14.6%), L5 (17.3%), and sacrum (4.8%). The biopsy specimens were sent for HPE, Gram staining, Urine full examination and microscopic examination (FEME), for example, acid-fast bacilli, cultures and sensitivities, and polymerase chain reaction for mycobacterium DNA. Correlations are also made with regard to the laboratory investigations of serum erythrocyte sedimentation rate, C-reactive protein, and serum tumor markers, i.e. carcinoembryonic antigen, alpha fetoprotein, prostate-specific antigen, and carcinoma antigen (CA)-125 and CA-19. There were 21 cases with tumor etiology (14 metastasis, 2 malignant round-cell tumor, 2 multiple myeloma, and 3 lymphomas), 14 TB, 4 osteomyelitis, 2 inflammatory, and 1 isolated compression fractures. Twelve patients of the 14 diagnosed cases who were diagnosed with TB on histopathology had positive TB culture and sensitivity patterns. Two patients with evidence of inflammation but no positive culture had undergone a repeat biopsy that also was without malignant disease and with negative culture.

All patients had postprocedure localized pain, which got relieved on analgesic medication. Only one patient had complained of persistent pain at the biopsy site, which subsided on analgesic treatment. One patient had previously undergone a CT-guided biopsy and the report was inconclusive. On performing fluoroscopic percutaneous transpedicular biopsy in this patient, a confirmed diagnosis was achieved. Complications in the form of bleeding, infection, neurologic deficit, or internal organ damage were not seen. The patient outcomes were consistent with the histopathological diagnosis. We did not find evidence of needle tract contamination by infection or malignancy.

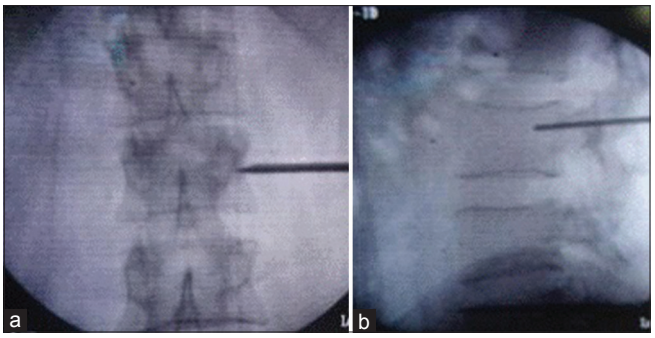

Figure 4: Anteroposterior (a) and lateral (b) views of the lumbar spine on fluoroscopic imaging with a marker placed at L2 vertebra

DISCUSSION

Percutaneous needle biopsy of spinal lesions can be performed on an outpatient basis, with a low rate of complications such as bleeding, infection, and contamination of the biopsy tract. In addition, if indicated, it permits subsequent radiotherapy avoiding wound-related problems. The procedure can be performed under local anesthesia and conscious sedation. This provides monitoring of nerve root function during the procedure and helps to minimize morbidity. Percutaneous biopsies may be done under fluoroscopic guidance or CT-guided biopsy may be done. Although CT-guided biopsy seems to offer accurate identification of the lesion, there are several disadvantages such as cost, radiation, continuous monitoring is not possible, and real-time positioning of the needle is also not possible. Fluoroscopy technique offers several advantages such as it can be done in a well-equipped room under aseptic conditions, and in case of a major complication, operative intervention may be undertaken immediately. Real-time positioning of the needle is possible and the amount of radiation is also low as compared to CT-guided biopsy.[8] The transpedicular approach vertebral lesions located immediately anterior to the pedicle and disc space both are accessible. Complications of this technique occur when the medial or inferior walls of the pedicle are violated, resulting in spinal cord damage or nerve root injury. Furthermore, if the biopsy needle penetrates too deeply, it can puncture the aorta or inferior vena cava.[9]

The lateral route provides a wide field for needle insertion, allowing access to the lateral wall of two adjacent vertebral bodies and the intervertebral disk.[10] The oblique direction of the needle is easy to maintain, and the needle is a safe distance away from the nerve roots, kidneys, renal pedicle, and large vessels. However, this approach should not be

used if the forward displacement of the abdominal contents is too small for a safe procedure. Transpedicular biopsy of the spine is a relatively common approach for both biopsy and vertebroplasty. A potential pitfall of the transpedicular approach, which occurs when the pedicle is not involved by tumor, is the possibility of obtaining a false-negative biopsy result.[11] The solution in such cases is to take deeper and multiple samples.

When aspiration biopsy is anticipated, it should be performed prior to obtaining any core specimens since the core biopsy can create a hemorrhagic tract that prevents successful aspiration of the desired abnormal tissue. Successful aspiration biopsy requires a secure fit between the aspirating syringe and the needle hub to facilitate forceful suction. Full negative pressure is generated using a 20-mL syringe while the needle is being advanced and retracted within the lesion. The distance of the needle excursions depends on the lesion size; large lesions permit safer, longer excursions, and short excursions are required for small lesions adjacent to critical structures The published accuracy of aspiration biopsy is series dependent and ranges from 23% to 97%.[12] Specific instances do occur in which percutaneous biopsy may be unsuccessful, yielding either no specimen or one that proves to be nondiagnostic. The bony elements of the vertebrae consist of round, hard surfaces. Securing purchase on their normal hard cortex can be difficult when the target lesion lies deep into the normal bone. In cases of heterogeneous lesions that are predominantly either cystic or necrotic, it may not be possible to harvest satisfactory specimens despite multiple attempts. Several maneuvers can be attempted to obtain a specimen. Slight, gentle rocking of the needle may allow separation of the specimen from the parent bone. If the lesion is large enough and there is a margin of safety, then advancing the biopsy needle slightly may enable retention of the bone core within the chamber of the biopsy needle. Applying suction to the biopsy needle with a 20 mL syringe may also facilitate a successful biopsy. Some single-pass bone biopsy needles come with an inner cannula that is partially truncated near its tip to trap the bone core within the parent needle chamber. Alternatively, if the sample size remains unsatisfactory for diagnostic purposes, a larger gauge needle system can be used to obtain a specimen. Other reasons for a nondiagnostic result include biopsies that are limited either by small lesion size or because too few passes were made with the biopsy needle. Hypervascular lesions can be difficult to sample since the brisk bleeding that can potentially occur with the initial access to the lesion can terminate the procedure. The intraosseous blood that is often aspirated during the bone biopsy is sometimes erroneously discarded. This osseous blood should be considered to be a biopsy specimen and should be submitted for pathological analysis since it is possible to diagnose malignancy from this tissue. Occasionally, a discrepancy in accounting for vertebral levels between different modalities causes the wrong vertebral levels to be sampled. Many spine lesions are identified on MRI, yet the percutaneous biopsy procedure is performed either with fluoroscopy or with CT. In certain situations, lesion conspicuity may be so much decreased with the latter modalities that optimal sampling is compromised. With respect to infectious spondylitis, the common reason for a nondiagnostic biopsy result is that patients are already being treated with antibiotics at the time of the procedure. Other reasons for a nondiagnostic biopsy result in spine infection include a failure to perform the correct microbiological testing (such as not performing an acid-fast bacillus stain or culture), dismissing as contaminants unusual microbes that may in fact be the causative agents, improper specimen handling or transport (not using anaerobic culture media when these organisms are suspected), or failing to follow specific cultures (*Mycobacterium tuberculosis*) for an extended period of observation. There are two types of transpedicular failure that can be encountered: (1) if there is a lytic lesion distal to the healthy or sclerotic bone and larger bore instruments like trocar instruments and (2) if there is a sclerotic lesion distal to the pedicle. The accuracy rate for lytic lesions is higher than those of sclerotic lesions.[13] It has been recommended to biopsies from the least dense area in a sclerotic lesion and with larger bore instruments like trocar instruments.[14] An experienced bone pathologist is an important factor for the diagnosis of spinal lesions and grading of tumors.

Posterolateral needle biopsy of vertebral lesions has been associated with complications such as nerve root injury, pneumothorax, hematoma, and bleeding from the trephine guide in up to 20% of cases, especially during biopsy of neoplastic lesions.[15] Careful preoperative assessment of the location of the lesion using CT and MRI is important in determining the site of the portal, thereby avoiding injury of vital structures. Using a biopsy trocar with the appropriate diameter and collecting the tissue specimen with minimal artifacts are important for effective bone biopsy.

Bone cores for histologic examination should be larger than 2 mm in diameter.[16] On the other hand, larger needles may injure nerves or vessels and disseminate malignant tumor cells. Thus, the optimal diameter of the biopsy needle remains an important issue.

Advantages of fluoroscopy-guided transpedicular trocar biopsy

Often, vertebral lesions are relatively small, with no extraosseus extension, and the location often is centrally

or anteriorly in the vertebral body. Through a unilateral pedicular channel, more than 50% of the vertebral bodies are accessible for biopsy.[17] In percutaneous transpedicular biopsy, there are minimal damage and contamination of normal tissue. The small wound heals rapidly and causes no interference with subsequent radiotherapy. The relatively narrow track of the Jamshidi trocar preserves the supporting tissue, thus preventing the local hemorrhage sometimes associated with open biopsy. The smaller specimen of bone obtained with this biopsy procedure is decalcified more rapidly, and sectioning can be expedited. In contrast, open biopsies of the bone often yield large blocks, which may take longer to process. Most patients can tolerate this procedure easily. With increasing experience, most of the transpedicular biopsies can be done on patients with the use of local anesthesia, and therefore, premedication is not essential. General anesthesia usually is required only in children or patients who are unable to remain still and where acute local tenderness is present. These potential complications can be avoided with the transpedicular approach because of its shorter needle tract with a small incisional wound and because of the containment of bleeding, infection, and spread of tumor within the cortical bone.

CONCLUSION

Fluoroscopy-guided percutaneous transpedicular biopsy of the thoracolumbar spine is a safe and effective tool in the diagnostic workup of a patient with a spinal lesion of uncertain cause. Percutaneous transpedicular biopsy of spinal vertebral lesions can be done safely under local anesthesia with a high incidence of positivity, helping in clinching the diagnosis, and can be performed as a day-care procedure. Percutaneous transpedicular biopsy is efficacious, safe, and cost-effective and mostly performed under local anesthesia. Fluoroscopic monitoring enables real-time positioning of the needle. Serious needle complications from percutaneous needle biopsy are uncommon. More than 50% of vertebral body tissues, including the disc, are accessible via a unilateral transpedicular approach and amenable for biopsy.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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