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CLINICAL REPORT

Epidural anesthesia with intravenous dexmedetomidine sedation in the successful anesthetic management of MRI-guided focused ultrasound ablation of early prostatic cancer

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Abstract We report on five patients who underwent MRI-guided focused ultrasound ablation of prostatic cancer under epidural anesthesia with intravenous dexmedetomidine sedation. This pioneering procedure requires an immobile therapeutic field with adequate sedation and analgesia provided to the patients. Duration of the procedure is longer compared to diagnostic MRI scans. In combination with epidural anesthesia, dexmedetomidine was used to provide moderate levels of sedation without causing respiratory depression or hemodynamic instability, and was useful in preventing shivering. The pharmacological properties of dexmedetomidine contribute to make this technique safe and effective.

Keywords Alpha 2-adrenergic agonist · Focused ultrasound ablation · Dexmedetomidine · Shivering · Remote anesthesia

Introduction

Magnetic resonance imaging (MRI)-guided focused ultrasound (MRgFUS) thermal ablation of prostate is a novel procedure in the therapy of early-stage prostatic cancer [1, 2]. High-intensity ultrasound is delivered to the prostate under real-time temperature control with MRI to produce irreversible thermal damage in the gland. The goal is to provide minimally invasive treatment for localized prostate cancer for which the current surgical option of radical prostatectomy is associated with a high rate of urinary and bowel complications [3]. For the group of patients who have elected for watchful waiting, this could provide another potential therapeutic option. Although its role in the management of prostatic cancer remains to be clearly defined, the anesthetic challenges and requirements are significant.

MRgFUS involves the following steps and is comparatively longer in duration than most MRI diagnostic scans. (1) Patient preparation and position: The anesthetized patient is placed in a supine position on the MRI table, and a rectal ultrasound probe is inserted. The table is then shifted into position with the pelvis at the focal point of the MRI tunnel. (2) Three-dimensional target localization and treatment planning: Images are acquired to locate the prostatic lesion(s) and surrounding organs. The contours of the treatment area are drawn on the MR image and verified in three orientations. The simulated ultrasound beam is then visualized to verify a safe treatment plan. (3) Treatment: Treatment consists of multiple ultrasound sonifications to ensure tumor ablation. During each ablative attempt, phase-sensitive MR images are acquired, and real-time quantitative temperature maps are produced to confirm tissue heating and to provide feedback for the physician to adjust treatment parameters to optimize thermal ablation. (4) Treatment outcome: Contrast-enhanced MR images are then acquired to detect regions without contrast agent uptake (nonperfused) to denote treated areas and to decide whether further ablation is required.

The pertinent anesthetic challenges for this MRI-guided technique are significant. There must be minimal movement during MRI scans because movement artifacts can result in suboptimal image quality. A crucial part of the procedure

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calls for immobility during the ablation of the prostate with the focused ultrasound, as any unwanted movement can potentially lead to iatrogenic injuries to neighboring organs [4]. The duration of the procedure can be significantly protracted by the need to calibrate the MRI images to the ablation probe as well the time taken for the actual ultrasound ablation procedure [5]. This protraction can lead to patient discomfort, resulting in inadvertent body movement during the procedure. The MRI suite is also cooled for equipment purposes, which can lead to hypothermia in the unprotected patient [6]. Prostate MRI scans, in contrast to neuroimaging, require the patient to be positioned deeper in relationship to the MRI tunnel because the pelvis must be at the focal point. Also, this facilitates the insertion and adjustment of the rectal ultrasound probe that is used for the ultrasound ablation. The patient's head is thus located within the MRI tunnel, leaving little room for airway interventions, and oversedation is a real hazard. The demographics of the patient population are also associated with multiple comorbidities that will require closer monitoring.

We present our initial experience with five patients who have undergone this procedure in our institution and the considerations for the anesthetic management that was chosen. With advances in therapeutics from minimally invasive surgery to MRI-guided ultrasound ablation now, anesthesiologists must learn to adapt their techniques. In particular, we found that the combination of epidural anesthesia with dexmedetomidine sedation to be safe, effective, and advantageous.

Case reports

Five patients underwent the prostatic ablation under epidural anesthesia with intravenous dexmedetomidine for sedation. The demographics of the patients and pertinent intraoperative details are summarized in Table 1. As per protocol of this study, only American Society of Anesthesiologists (ASA) status 1–2 patients were selected.

Following informed consent and application of routine monitors in the anesthesia induction room, an epidural catheter was placed at the L4–L5 level with 5 cm of the catheter in situ. The epidural anesthesia was then established with 20 ml 0.5% bupivacaine in divided aliquots after a test dose of 3 ml 1.5% lidocaine. Upper limit of loss of sensation to an ice-block and Bromage score was recorded. The patient was then transferred to the MRI scan room after 15 min of monitoring. Motor block of both legs was tested using a modified Bromage scale: 0 = full movement; 1 = inability to raise extended leg, can bend knee; 2 = inability to bend knee, can flex ankle, 3 = no movement. If the patient had a Bromage score of <3 in the MRI scan room, a further epidural top-up of 10 ml bupivacaine in divided aliquots was given. Thereafter, an epidural infusion of 0.5% bupivacaine at 10 ml/h was commenced. A dexmedetomidine loading dose of 0.5 μg/kg was administered over 10 min, followed by a continuous infusion at 0.3 μg/kg/h with a range of 0.2–0.7 μg/kg/h titrated to Ramsay Sedation Score of 3–4. Standard parameters were monitored throughout the procedure. At the cessation of the procedure, both epidural and dexmedetomidine infusions were stopped. The patient was then transferred back to the induction room where the epidural catheter was removed.

Discussion

The MRI suite as a remote anesthetic location has become increasingly popular as longer and more invasive

Table 1 Demographics and perioperative details

Patient	A	B	C	D	E
Age (years)	68	58	59	65	60
Weight (kg)	71	69.5	66.5	64	75
Coexisting diseases	HPT, DM, IHD	Nil	HPT	Nil	HPT
Antihypertensives	Lisinopril, amlodipine	Nil	Atenolol	Nil	Enalapril
0.5% Bupivacaine					
Induction (ml)	20 + 10	20 + 10	20	20 + 10	20 + 10
Maintenance (ml)	40	50	45	60	46
Dexmedetomidine					
Induction (μg/kg)	0.5	0.5	0.5	0.5	0.5
Maintenance (μg/kg/h)	0.3	0.3	0.4	0.5	0.5
Lowest temperature (°C)	35.0	34.0	34.7	36.0	36.0
Duration in scan room (min)	230	305	265	420	215

HPT hypertension, *DM* diabetes mellitus, *IHD* ischemic heart disease radiologic scans are performed with the improvement in scanning technologies. As a result, sedation requirements have increased, and anesthesiologists are increasingly being called upon to assist in such procedures as deeper planes of sedation and anesthesia are desired. MRI requires a motionless scanning field for optimal image acquisition and, in this novel MRI-guided interventional procedure using focused ultrasound for thermal ablation of the prostate, inadvertent patient movement can lead to iatrogenic injuries to peripheral organs.

The anesthetic requirements are significant as the procedure can be extremely uncomfortable in the conscious patient. The rectal probe used for the ablative procedure is 2.7 cm in diameter and cooled to a temperature of 4°C. It is inserted to the depth of the patient's sacrum and remains in position throughout the entire procedure. The duration of the whole procedure is quite protracted, ranging from 215 to 420 min (mean, 287 ± 82). Other physical discomfort includes a rise of temperature within the prostatic tissue during the ablative procedure to about 65°–85°C.

The use of regional anesthesia via an epidural block with sedation technique for five patients was utilized to avoid the hazards of general anesthesia in a remote MRI environment [7]. This technique produced satisfactory imaging and interventional conditions. Epidural anesthesia provided an immobile field and blunted the response to rectal probe manipulation and the heat generated by the focused ultrasound ablation.

Dexmedetomidine is a highly selective alpha-2 adrenoreceptor agonist that is increasingly used for sedation in areas outside the operating room and intensive care unit. We considered the use of dexmedetomidine for sedation because of its unique sedative properties. Dexmedetomidine has a favorable pharmacological profile that can provide patient comfort, sparing respiratory depression even at large doses [8], and is potentially an ideal sedative for this procedure. Although there are concerns with hypotension and bradycardia, it has a relatively stable hemodynamic profile [9]. A comparative MRI sleep study between dexmedetomidine and propofol demonstrated the advantages of dexmedetomidine with less need for airway intervention [10]. It is safe in the elderly [11].

The procedure times were expectedly long because of the pioneering aspect of this procedure and the multistep sequence of therapy. It was deemed unlikely that the patient could remain immobile for the duration despite an adequate epidural blockade. Unintended upper body movements by the patient can lead to procedural problems ranging from image capture deterioration to iatrogenic thermal damage to neighboring organs. The analgesic component of dexmedetomidine is useful in ameliorating the other physical discomforts that the patient might feel in such an environment.

The pharmacological advantage of dexmedetomidine in prevention of postanesthetic shivering was previously documented [12, 13]. Shivering is expectedly detrimental to image quality, and its minimization in the unparalyzed patient is desired. Maintaining a comfortable and adequate temperature for the patients was particularly challenging in the typically low-temperature MRI suite, and this is further aggravated by the cooled rectal probe. Despite using warm blankets and replacing them during scanning intervals, the lowest temperature recorded ranged from 34.0° to 36.4°C with the lower extreme related to a longer procedure time. Dexmedetomidine was instrumental in the prevention of shivering in those moderately hypothermic patients and assisted in ensuring adequate image quality and patient comfort.

The increase in procedure time had a direct correlation to the dose of local anesthetic received. Although we remained within conventional dosing guidelines for bupivacaine, we acknowledge that a less cardiotoxic local anesthetic such as ropivacaine could have been used.

This case series has demonstrated that epidural anesthesia with sedation is a viable technique in a suitable long-duration procedure. In particular, intravenous dexmedetomidine sedation should be considered for its pharmacological advantage of hemodynamic stability, minimal respiratory depression, analgesia, and amnesia [14], with the added advantage of shivering prevention.

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