Internal Skin Burn Due to Novel Radiofrequency Ablation Technology

Zachary L. McCormick, MD; Brian Chung, MD; and Clark Smith, MD, MPH on behalf of the Spine Intervention Society’s Patient Safety Committee

1 University of Utah, Division of Physical Medicine and Rehabilitation, Salt Lake City, Utah, U.S.A.;  
2 Department of Anesthesiology, Division of Pain Medicine. Northwestern University Feinberg School of Medicine. Chicago, Illinois, U.S.A.;  
3 Columbia University Medical Center, Rehabilitation and Regenerative Medicine, New York, New York, U.S.A.

Myth: Internal skin burns do not occur during radiofrequency ablation of medial branch nerves or sacral lateral branch nerves because the lesions produced are too small to reach the overlying skin.

Fact: Internal skin burns have been described as complications of novel RFA technology, including water-cooled and multi-electrode devices.

Radiofrequency ablation (RFA) has been used to denervate painful joints for over 40 years, predominantly the zygapophysial and sacroiliac joints [1, 2]. The size of RFA lesions depends on the gauge of the electrode used, the length of its active tip, lesion duration, and lesion temperature. A typical monopolar RFA lesion has a volume of 0.7 cm$^3$ and a diameter of 0.9 cm [3]. Even when cannula size and duration/temperature parameters are maximized, monopolar lesions are not likely to expand beyond 0.9 cm$^3$ and 1.1 cm [3].

Various new RFA technologies have been developed in order to facilitate the ease and efficiency of RFA denervation procedures. These novel devices increase lesion volume, increase lesion projection beyond the electrode tip, or create multiple simultaneous burns [4-8]. While such innovation may confer certain technical advantages compared with traditional thermal RFA, the potential arises for complications due to increased lesion size.

In 2014, Roussis and Walega reported a case of a full-thickness skin burn during a thoracic medial branch RFA using water-cooled technology in a thin patient (BMI 20.8 kg/m$^2$) [9]. The skin burn was 20 mm in diameter, and developed within 90 seconds of lesioning a T2 medial branch using an 18 gauge electrode with a 5.5 mm active tip. The authors noted that, throughout the procedure, they manually secured the probe to prevent migration during lesioning, and checked probe position using fluoroscopy. There was no apparent abnormality or damage to the probe, grounding pad, or generator system.

Two explanations for this complication can be raised based on the mechanisms of water-cooled RFA. Circulating water internally through the electrode cools its surface, which prevents coagulation of tissues adjacent to the electrode [7, 10]. In turn, this decreases tissue impedance, which allows the RFA lesion to expand to a larger volume [8]. In particular, the lesion extends significantly beyond the tip of the electrode [8]. Because of this forward projection, some physicians might choose not to advance the electrode to full depth onto a target nerve, which could allow the proximal end of the RFA lesion to reach the overlying skin. Alternatively, the RFA lesion produced may be larger than expected. Although water-cooled lesions have been studied in animal tissue or human cadavers [3, 8, 11], the exact size of lesions produced in patients is not known. The manufacturer of the water-cooled system used in this case report predicts a lesion size of 10-12 mm, but this may be an underestimate. The skin lesion in this case was measured to be 20 mm.

We report an additional case of a full-thickness burn that occurred in association with use of a multi-electrode RFA technology. The patient underwent RFA of the sacral lateral branches using radiofrequency electrodes placed simultaneously at three sites. Monopolar lesions are created at each site, and bipolar lesions between sites one and two, and two and three. This creates a “strip-lesion” 9 mm x 52.5 mm in dimension [6, 12]. As instructed by the manufacturer [12], each probe was inserted parallel to the surface of the sacrum, with the first electrode lateral to the S1 posterior foramen, the second lateral to the S2 foramen, and the third electrode lateral to the S3 foramen. In these positions, lesions were created at 80°C for 60 seconds. In order to ensure complete lesioning of the S2 and S3 lateral branches, the rostral electrodes were subsequently each withdrawn slightly, such that the most rostral electrode (originally at S1) was repositioned lateral to the S2 sacral foramen, and the middle electrode (originally at S2) was repositioned lateral to the S3 foramen. The third probe (originally at S3) was also withdrawn slightly, and rested in soft tissue beneath the skin’s
surface. According to the manufacturer, selective lesions can only be performed via the rostral two electrodes. The operator attempted to activate only these two electrodes, but the third electrode (resting in soft tissue beneath the skin) was unintentionally active during this subsequent lesion, creating a third-degree skin burn approximately 15 mm in diameter at the point of insertion of the third electrode (Figure 1).

Although multi-electrode RFA might appear to provide greater efficiency in lesioning the sacral lateral branches compared with the traditional bipolar “leap-frog” or “strip-lesion” method using conventional thermal RFA probes, this technology introduces the possibility of unintentional skin burn. There appears to be no protective mechanism against unintentionally activating the proximal electrode when it is positioned too superficially. Furthermore, although the manufacturer predicts a lesion that is 9 mm in diameter [6, 12], the skin burn observed in this case was 15 mm in diameter.

These are the only two cases of skin burns reported in the medical literature. However, this complication may be more common than this paucity of literature suggests because of the adverse legal implications of reporting complications [13]. Nevertheless, the cases provide proof of principle that skin burns are possible. They warn physicians to understand the potential size and shape of lesions that they produce, and how they might affect overlying tissues that are not the target, particularly in thin patients. Lesions produced may be larger than suggested by the manufacturers. The location of electrodes should be checked and monitored in case they are wrongly positioned or migrate during the procedure. In particular, caution should be exercised when using multi-electrode RFA, so that ostensibly inactive electrodes are not inadvertently activated.

References