Development of an Endocardial Cryoablation Catheter for Concomitant Delivery of Cryogenic Treatment and Adjuvants

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This paper presents the preliminary development of a novel cryoablation catheter for the delivery of cryo-energy and complimentary pharmacological agents selected to improve lesion formation. The described prototype uses a commercially available cryoablation catheter with a deployable needle injection catheter grafted onto it. The device would be used in endocardial ablation of thick structures and would inject an adjuvant at the desired depth prior to cryotherapy delivery. Adjuvants have been investigated previously to increase the “kill zone” of an ablation lesion and can minimize the zone of incomplete death near the iceball edge. This makes visualization of the iceball via ultrasound a better predictor for lesion size and progression. Transmurality of a lesion can be essential for a clinical ablation procedure to have long-term effectiveness. The secondary goal of such a device may be to increase energy transfer via the metal needle in the myocardium, so to further aid in the creation of transmural lesions in thick tissues (e.g., the ventricles). Added embodiments of such therapeutic devices would be to also have electrical pacing/sensing capabilities and/or temperature monitoring capabilities at the tip of the needle. Such features would likely provide a physician with more precise information regarding lesion progressions and efficacies. One potential device design could therefore have two temperature sensors, one at the ablative tip and one at the needle tip. This will allow the user to monitor how far and how fast the lesion has advanced into the myocardium at the preset depth of the needle. After the lesion is formed, entrance and exit block tests could then be used to evaluate the ability of the lesion to block electrical propagation. A unique feature of this catheter design approach is the method of active deployment. The physician will preset a desired needle deployment depth and then navigate the catheter to the location of treatment. Next, the cryocatheter would be positioned and frozen to the desired location of the endocardium, when appropriate, the needle would then be deployed, perhaps by first applying a rf energy to warm the system within the created iceball so to allow needle to be actively plunged into the myocardium. Subsequently, the contact of the needle to the cryocatheter system will rapidly cool the needle within the engaged myocardium. This approach could potentially reduce the risks of perforations and ensure consistent deployment depths. As found in the literature, and during preliminary testing, lesion size can be readily increased using the focal delivery of a high NaCl infusion, prior to energy application. We consider here that it should be possible to create the final embodiments of such devices with additional pacing/sensing, temperature monitoring, and active deployment: This should be technologically feasible using commercially available products and stereolithography (SLA) rapid prototyping.

Sensorless Haptic Feedback in a Surgical Robot for Telesurgery

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In order to regain haptic feedback when utilizing robot-assisted surgical techniques in the telesurgery, various methods have been utilized. Toward this effort, the most widely used method of utilizing sensors to measure the interaction force between tissue and surgical instruments has inherent drawbacks such as increased size and cost due to the additional sensor modules. In this paper, an alternative sensorless method has been proposed to estimate the interaction force for a surgical robot in telesurgery. This novel method utilizes a calculation algorithm based on accurate dynamic modeling of the robot and the relationship between a motor’s current and torque. Employing this algorithm will resume haptic feedback sensorlessly in telesurgery and simplify the robotic structure, thereby reduce the associated costs. This sensorless force estimation method presents an effective haptic feedback approach for general on-board actuated surgical methods or applications. It is still applicative when the master console and the slave robot are built in dissimilar multi-degree-of-freedom architectures. Consequently, this algorithm will significantly usher the revolution of applications in surgical robotic fields.

