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Subcutaneous Tissue Transient Thermal Profiling Under RF-energy Pulsed Wireless Supply to 3W-8W Rated LVAD in the Living and Cadaver Models

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Abstract-

Introduction
Left Ventricular Assist Devices (LVADs) are used as a bridge to cardiac transplantation, and for long-term support in patients with advanced Heart Failure. LVADs are relatively high-power demanding implanted devices (>3W), provided via a percutaneous driveline (cable) from an external supply. However, incidence of driveline infection is a severe and frequent drawback. Wirelessly Pulsed Energy Transmission (WPET) transcutaneously is aimed to mitigate tissue-heating effects over conventional non-pulsed Transcutaneous Energy Transfer Systems (TETS). We comparatively assess the transient thermal profile of WPET in living and cadaver porcine models.

Methods
Dual-channel WPET pulsed and continuous TETS systems were investigate to characterise subcutaneous tissue transient thermal profiling for several ratings of RF-power losses between the primary and the implanted coils. Twelve Negative-Temperature-Coefficient thermistors were adhered at the surface of the implanted coils to monitor the thermal profiles for 3W, 5W, 6W, and 8W rated LVADs. The implanted coils (channel-1 and channel-2) are placed at about 6-10 mm underneath the skin surface. RF-transmission pulse duration ranged from 30ms to 480ms, and idle time (no-transmission) from 5s to 120s. Temperature change of the tissue were sensed by the 12-thermistor.

Results
The average transient thermal profile of the living-model measurement, both in pulsed and continuous power transmission heating losses, are presented in Table1 below. The transient thermal profile of subcutaneous tissue shows an almost similar profile at low power levels (3W); however, 6 and 8 Watts pulsed transmission showed a significantly lower temperature profile. Table 2 presents the transient temperature profile of the cadaver model which indicated that in the cadaver model, the tissue heating is significantly higher in the absence of blood-perfusion.

Conclusion
We developed and evaluated the transient thermal profile of both RF pulsed and continuous TETS systems. The pulsed system would suit high-power LVADs with minimised subcutaneous tissue heating effects via blood-perfusion.

Table 1. Average transient thermal profile of the living-model.

Power (W)	Pulsed transmission		Continuous transmission	
	Ch.1(°C) ±SE (ΔT)	Ch.2 (°C) ±SE (ΔT)	Ch.1 (°C) ±SE (ΔT)	Ch.2 (°C) ±SE (ΔT)
3	$0.85 \pm 1.75 \times 10^{-2}$	$1.19 \pm 1.78 \times 10^{-2}$	$0.99 \pm 3.05 \times 10^{-5}$	$1.19 \pm 3.08 \times 10^{-5}$
6	$1.58 \pm 1.60 \times 10^{-2}$	$1.86 \pm 2.01 \times 10^{-2}$	$1.92 \pm 2.86 \times 10^{-5}$	$2.22 \pm 4.49 \times 10^{-5}$
8	$1.95 \pm 1.93 \times 10^{-2}$	$2.49 \pm 2.23 \times 10^{-2}$	$2.41 \pm 6.60 \times 10^{-4}$	$3.05 \pm 1.32 \times 10^{-3}$

Table 2. Average transient thermal profile of the cadaver-model at 5W.

Power (W)	Pulsed transmission		Continuous transmission	
	Ch.1(°C) ±SE (ΔT)	Ch.2 (°C) ±SE (ΔT)	Ch.1 (°C) ±SE (ΔT)	Ch.2 (°C) ±SE (ΔT)
5	$3.43 \pm 8.86 \times 10^{-3}$	$3.60 \pm 1.03 \times 10^{-3}$	$3.52 \pm 8.28 \times 10^{-4}$	$3.84 \pm 9.67 \times 10^{-4}$