REAL-TIME INTERACTIVE 3D SIMULATION OF TEMPORARY CARDIAC PACING

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Background: In response to the COVID19 pandemic the UK NHS confirmed that more than 4,000 retired healthcare workers had signed up to help battle the outbreak. At the same time large numbers of doctors and nurses of all specialties were being diverted to Intensive Care Unit (ICU) management. Evidently there was a sharp increase in demand for rapid clinical training. Temporary Cardiac Pacing (TCP) is one of the critical interventions in ICU patients with acute respiratory distress syndrome. It is an intervention that helps the heartbeat get back to normal rhythm. Traditionally training for TCP takes place on the patient.

Objective: In order to address the increased need for rapid training, we set out to adapt our heart simulator for ICU procedure training and provide a simulation-bases eTraining solution for TCP.

Methods: We developed an application for TCP eTraining, accessible on tablets and smart phones. The app is based on our validated electromechanical simulation model of the heart and realtime interactive 3D simulation technology. The app content consists of a virtual heart in various arrhythmic states. A simulated interactive pacemaker is connected to the heart model and is capable of generating realtime changes in pacing location, rate, voltage, sensitivity and mode. Real-time ECG signals are being recorded on the virtual heart and are used to monitor the effect of the pacemaker. Self-study tutorials introduce the procedure and tests allow trainees to assess their learning outcomes.

Results: The app has received CPD accreditation in the UK and has so far been used at the University of Oxford, University of Leeds and Middlesex University. All trainees, medical students and trainee nurses followed the self-study tutorials and took the MCQ and interactive test which are embedded within the TCP app. Development was based on Unity 3D and was made available on iOS, Android, macOS, Windows and WebGL platforms.

Conclusion: This project allowed us to meet an urgent training need and at the same time expand our expertise and market scope into clinical training. The impact on clinical training was high and the societal benefit came from better and quicker trained staff. The project was funded by an Innovate UK grant.
Background: The implantation of a leadless right ventricular pacemaker (LPM) may be complicated by tricuspid valve injury or interference with tricuspid valve function.

Objective: Characterize the nature, causes, and outcomes of tricuspid valve injury and functional interference due to LPM implantation.

Methods: The Food and Drug Administration’s Manufacturers and User Facility Device Experience (MAUDE) database was queried for tricuspid valve adverse events involving the Medtronic Micra LPM that were reported by the manufacturer.

Results: From 2016-October 2021, 19 patients suffered a tricuspid valve adverse event, including damage to the leaflets, papillary muscle, or chordae tendineae (n=14; 74%); interference with valve closure (n=3; 16%); and 2 LPMs were irretrievably wedged in the tricuspid valve apparatus. Damaged valves included: 1) torn leaflet or chordal tissue found in the delivery system (n=6) after complicated or failed LPM recapture that necessitated removal without the LPM retracted into the delivery system; all patients developed tricuspid regurgitation, and one patient died. 2) valve damage by the delivery system either directly (n=6) or during LPM recapture (n=1) or removal by a snare (n=1); all patients had new or worsening tricuspid regurgitation; one patient died, 2 had valve repair, and one valve was replaced. In three patients the LPM interfered with valve function; one had valve replacement, one underwent LPM removal, and one was treated medically. Of the 2 LPMs wedged in the tricuspid valve apparatus, one required surgical removal and one was abandoned.

Conclusion: Tricuspid valve trauma during LPM implantation may cause significant regurgitation that results in poor outcomes and requires medical or surgical intervention. Mechanisms include direct valve injury by the delivery system, complications of attempted LPM recapture, and LPM interference with valve function.

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GUIDELINE DIRECTED MEDICAL THERAPY AND THE RISK OF DEATH IN PRIMARY PREVENTION DEFIBRILLATOR RECIPIENTS

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Background: Primary prevention implantable cardiac defibrillators (ICD) are indicated in patients with heart failure and severely reduced ejection fraction (EF). Quadruple guideline-directed medical therapy (GDMT) with ACE inhibitors/ARB/ARNI, beta-blockers, aldosterone antagonists, and SGLT-2 inhibitors is indicated in this population.

Objective: To investigate the impact of number of GDMT medications prescribed at the time of device implantation on all-cause mortality at one year in primary prevention ICD recipients.

Methods: We analyzed data from 4,972 ICD and cardiac resynchronization therapy ICD (CRT-D) recipients at our institution, based on the sum of GDMT medications prescribed. We examined mortality using Cox multivariable models adjusting for age, EF, and the Elixhauser comorbidity score.

Results: Our cohort had 5%, 20%, 52%, 22%, and 1% of patients prescribed 0, 1, 2, 3, or 4 GDMT, respectively. In the multivariable models, use of each additional GDMT conferred a 41% reduction in the risk of death in ICD recipients (adjusted HR=0.59, p<0.001) (Figure 1A) and a 30% reduction in the risk of death in CRT-D recipients (adjusted HR=0.70, p=0.006) (Figure 1B). Among patients on quadruple GDMT, 1-year mortality was 2% in ICD and 0% in CRT-D recipients.

Conclusion: A higher number of prescribed GDMT at the time of device implantation is associated with better longevity in primary prevention ICD recipients with or without CRT. Initiation of maximum tolerated GDMT medications should therefore be the goal in these patients. In the setting of optimal GDMT, the survival benefit of primary prevention ICD warrants re-examination in future studies.

Figure 1: Cumulative one year survival based on the number of prescribed GDMT medications in primary prevention ICD (panel A) and CRT-D (panel B) recipients.

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COMORBIDITIES, CLINICAL OUTCOMES AND PREDICTORS OF COMPLICATIONS IN PATIENTS WITH LEADLESS PACEMAKER

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Background: Leadless pacemakers have emerged as a viable alternative for traditional transvenous pacemakers to reduce the risk of device-related complications.

Objective: This study aimed to examine the real-world clinical outcomes and complications associated with implantation of leadless pacemaker devices.

Methods: Using the National Readmission Database, we examined patient demographics, in-hospital, and 30-day procedural outcomes after leadless pacemaker implantation from 2016-2018. Our cohort was comprised of all adults (>18 years) with an ICD-10 procedural code for leadless pacemaker implantation.

Results: Our cohort included a total of 7,821 patients that underwent leadless pacemaker implantation. Pericardial effusion without the need for pericardiocentesis occurred in 1.9% of patients, while pericardiocentesis was performed in 1.0%. Vascular complications occurred in 2.9% of patients. The most significant predictor for procedural complications was end-stage renal disease (OR 2.36, 95% CI 1.56-3.56, P < 0.002), chronic liver disease (OR 2.08, 95% CI 1.32-3.28, P < 0.019), coagulopathy (OR 1.57, 95% CI 1.08-2.29, P < 0.001), and female gender (OR 1.45, 95% CI 1.07-1.97, P < 0.001). All-cause readmission occurred in 17.9% of patients within 30 days from