White Rose Research Online

eprints@whiterose.ac.uk
https://eprints.whiterose.ac.uk
Universities of Leeds, Sheffield and York

Deposited via The University of Leeds.

White Rose Research Online URL for this paper:
https://eprints.whiterose.ac.uk/id/eprint/81597/

Version: Accepted Version

Article:

Ma'touq, J, Strauss, DN, Messenger, N et al. (2014) Spinal angle and foot pressure during cardiac electrophysiological procedures. International Journal of Cardiology, 172 (3). 398 - 400. ISSN: 0167-5273

https://doi.org/10.1016/j.ijcard.2013.12.260

Reuse
Items deposited in White Rose Research Online are protected by copyright, with all rights reserved unless indicated otherwise. They may be downloaded and/or printed for private study, or other acts as permitted by national copyright laws. The publisher or other rights holders may allow further reproduction and re-use of the full text version. This is indicated by the licence information on the White Rose Research Online record for the item.

Takedown
If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.

UNIVERSITY OF LEEDS
University of Sheffield
UNIVERSITY of York

Spinal angle and foot pressure during cardiac electrophysiological procedures

J. Ma'touq (MSc)[1], D. N. Straus (PhD)[2], N. Messenger (PhD)[2], T. D. Stewart (PhD)[1], M. H. Tayebjee (MD)[3]

[1] Institute of Medical and Biological Engineering, Faculty of Engineering, The University of Leeds, UK

[2] Sports and Exercise Sciences, Faculty of Biological Sciences, The University of Leeds, UK

[3] West Yorkshire Arrhythmia Service, Department of Cardiology, Leeds General Infirmary, UK

Short title : Foot pressure and spinal angle

Word count : 948

Corresponding author:

Dr. Muzahir Tayebjee

Department of Cardiology

Leeds General Infirmary,

Leeds,

LS1 3EX
United Kingdom
Muzahir.Tayebjee@leedsth.nhs.uk
Phone +44 113 3926619 Fax +44 113 3923981

Acknowledgment:

The authors have no competing interests. J. Ma'touq was supported by a Said Foundation Scholarship. This study was also supported by the National Institute for Health Research (NIHR) through funding of the Leeds Musculoskeletal Biomedical Research Unit (LMBRU). The Welcome Trust and EPSRC support WELMEC, a Leeds Centre of Excellence in Medical Engineering, under grant number WT088908/Z/09/Z. Ethical approval was obtained by MEEC Faculty Research Ethics Committee, University of Leeds, Ref:MEEC 11-026

Keywords: Posture, Biomechanics, Foot Pressure, Spine, Cardiac Electrophysiology

Procedures in interventional cardiology requiring the use of ionising radiation require the use of lead aprons (6-10kg). In invasive cardiac electrophysiology, procedures may have a duration of up to 8 hours that results in fatigue, orthopaedic problems (e.g. back and foot) and impaired venous return [1, 2]. There have been several qualitative (rather than quantitative) studies investigating the causal link between lead aprons use and musculoskeletal disorders [2-7].

In order to investigate the effects of wearing a lead apron on the spine and feet, a pilot biomechanical analytical study on a single interventional cardiac electrophysiologist was conducted.

One 37 year old male consultant interventional cardiac electrophysiologist performing invasive cardiac procedures for 10 years with no history of musculoskeletal disorders was analysed. The subject wore a wrap around lead apron that was not open in the back. The apron comprised a separate chest jacket and skirt with a belt. Spinal angles were assessed clinically using video images taken at 30 minute intervals using a Panasonic HDC-TM900 video camera (Panasonic UK Ltd.). Thoracic and lumbar angles were measured by manually drawing a tangent for the thoracic and lumbar segments of the spine. The methodology was initially validated using a 12 camera Qualisys ProReflex MCU240 motion capture system and C-Motion Visual 3D software in the Motion Analysis Laboratory where the electrophysiologists operating table and monitors were simulated. Analysis of ‘clinical’ spinal angles was completed at regular time intervals for 5 complete ‘live’ procedures. Assessment was also conducted in a ‘laboratory’ setting where the clinical procedures were simulated whilst the lead apron was not being worn.

The recording of foot pressure was completed using a Pedar X system (Novel-gmbh) in-shoe pressure measurement system. The signal was divided into nine zones to aid in studying changes in the centre of pressure. Filming and foot pressure measurement were synchronised manually to associate a given task or posture to the foot pressure measurement. Analysis of foot pressure was completed for 3 complete clinical procedures with the Pedar equipment calibrated prior to the study and the insoles were re-set to zero pressure prior to each procedure. Further analysis was also completed on three resting days (5 different recordings per day to assess variability) when the electrophysiologist performed no procedures and thus wore no apron as a method of comparing the clinical results to normal foot pressure.

Spinal angles and foot pressures were measured for four different common tasks of the electrophysiology procedure namely, standing in an upright position, looking at a high monitor, looking at a low monitor and looking at a side monitor. Results are presented by comparing the increase in flexion that occurred for each task compared to normal upright standing.

When a lead apron was worn the lumbar flexion angle increased by 11°, 23.9, and 4.7° , compared to upright standing, when looking at the high monitor, looking at the low monitor and looking at the side monitor, respectively. The corresponding increase in thoracic flexion angles, compared to upright standing, with the lead apron were 11.5°, 25.3°, 1.9° for the same activities respectively.

There was no significant difference in flexion angle increase when the electrophysiologist was analysed in the 'laboratory' when not wearing the apron (resting) compared to in the 'clinical' setting. Flexion angles were greatest when looking at the low monitor. Despite looking upwards at the high monitor the electrophysiologist tended to lean forwards during this activity.

Average and peak foot pressure for the three procedures were found to reduce on resting days and varied with time. Furthermore, high pressure regions were observed over a significantly greater area of the foot (Figure 1). In addition, as the procedure progressed the centre of pressure was observed to move towards the anterior aspect of the foot.

Interventional cardiac electrophysiological procedures require multiple changes in posture, bending and prolonged standing whilst wearing lead aprons. This is to allow a variety of tasks (including fine motor, and operation of foot pedals) to be completed as well as to facilitate the observation of multiple monitors often placed sided by side and above each other.

Increases in lumbar and thoracic flexion angles up to 25˚ were observed whilst the 6kg lead apron was worn and directly associated to the task completed. This finding is consistent with musculoskeletal adaptations during longer term lead apron wearing [7].

Foot pressure was shown to be highly variable and dependent upon weight distribution that shifted regularly during the operation from one leg to both legs. Standing for long periods of time whilst wearing a lead apron resulted in a 50% increase in both the mean and maximum peak foot pressures additionally moving the centre of pressure toward the forefoot region as the procedure progressed and the operator fatigued.

The study was conducted on a single operator, however the measurements were repeated for five procedures. Future work should focus on measuring the effects of wearing the lead aprons on different operators and at different times of the day. Equipment used for collecting data in the study was selected specifically as not to restrict the movement of the operator or influence the clinical environment limiting the measurement of spinal angles to a simple camera system.

We show for the first time how musculoskeletal stresses in the cardiac catheter laboratory can be quantified and provide data to document the effect on the foot and the spine. Further work is required to confirm these findings, and urgent solutions sought to seek preventative measures.

Informed consent was obtained from the electrophysiologist and the study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki. The authors of this manuscript have certified that they comply with the Principles of Ethical Publishing in the International Journal of Cardiology.

Author contributions.

Concept/design: TS, MHT

Data analysis/interpretation: JMT, DNS, NM, TS

Drafting article: JMT, TS, DNS, NM, MHT

Critical revision of article: TS, DNS, NM, MHT

References

1. Fadl, YY, Ellenbogen KA, Grubb RL Jr, Khoo-Summers L, Lindsay BD. A Review of Spinal Injuries in the Invasive Cardiologist: Part 1. Biomechanics and Pain Generation. Pacing Clin Electrophysiol. 2007. 30:1012-1019.
2. Goldstein JA, Balter S, Cowley M, Hodgson J, Klein LW. Occupational Hazards of Interventional Cardiologists: Prevalence of Orthopedic Health Problems in Contemporary Practice. Catheter Cardiovasc Interv. 2004; 63:407–411.
3. Ross AM, Segal J, Borenstein D, Jenkins E, Cho S. Prevalence of Spinal Disc Disease Among Interventional Cardiologists. Am J Cardiol. 1997;79:68-70.
4. Pelz, D.M., Low Back Pain, Lead Aprons, and the Angiographer. AJNR Am J Neuroradiol. 1999; 21:1364-000.
5. Klein LW, Miller DL, Balter S, Laskey W, Haines D, Norbash A, Mauro MA, et al. Occupational Health Hazards in the Interventional Laboratory: Time for a Safer Environment. J Vasc Interv Radiol. 2009; 20:147-152.
6. Meakin JR, Smith FW, Gilbert FJ, Aspden RM. The effect of axial load on the sagittal plane curvature of the upright human spine in vivo. J Biomech. 2008; 41: 2850-2854.
7. Johnson DD, Kirkpatrick AE, Ashton-Miller JA, Shih AJ. Effect of Lead Use on Back and Shoulder Postural Muscle Activity in Healthy Young Adults. Hum Factors 2011; 53: 729-739.

Figure 1. Typical foot pressure results when wearing a lead apron and not wearing a lead apron (rest day).