Lymphology 42 (2009) 139-145

AIRPLANE TRAVEL AND LYMPHEDEMA: A CASE STUDY

L.C. Ward, K.J. Battersby, S.L. Kilbreath

School of Chemistry and Molecular Biosciences (LCW,KJB), University of Queensland, Faculty of Health Sciences (SLK) , and The Breast Cancer Research Group (LCW,SLK), University of Sydney, Brisbane, Australia

ABSTRACT

A single subject prospective study of the relationship between air travel and lymphedema is reported. This proof of concept study was aimed at assessing the feasibility of using self-measured, inter-limb impedance ratios as a quantitative measure of lymphedema immediately prior to and following flying. The participant, a breast cancer survivor with lymphedema, measured whole arm impedance prior to and following air travel on 20 occasions, varying in duration of between 1 and 9 h, over a 12-month period. Although the inter-arm impedance ratio fluctuated over this time, it generally increased and worsened following flying. Impedance measurements were easily performed by the participant and could be obtained as close to the start and cessation of flying as is practicably possible. These data, when associated with self-assessment of lymphedema-related symptoms, could provide a comprehensive evidence base for an assessment of the risks associated with air travel and the provision of appropriate advice to prospective travelers. Further large-scale studies are recommended.

Keywords: impedance, lymphedema monitoring, air travel, self- assessment

Lymphedema is a chronic, debilitating condition generally characterized by swelling of a limb or limb region that may be painful, frequently limit limb function and mobility and contribute to a poorer quality of life of the affected patient. Lymphedema may be of primary or secondary aetiology, most commonly the latter, and result from surgical or radiation treatment of cancer, e.g., for breast cancer (1). The precise incidence of lymphedema secondary to breast cancer is unknown, but according to a recent review (2), estimates range between 24 and 49% depending upon the type of surgery. In the US alone there are estimated to be 400,000 women with lymphedema (3).

The precipitating factors for lymphedema are uncertain but are reported to include obesity, infections, prolonged use of the affected limb, as well as other factors such as pressure changes due to airplane travel. Consequentially, women at risk of developing lymphedema are frequently encouraged to undertake behavioral and lifestyle changes to minimize the risk. Unfortunately, the evidence for this advice may be, at worst, absent or, at best, anecdotal. A case in point is the purported potential for airline travel to initiate or to exacerbate pre-existing lymphedema (4). The rationale for such a view is that the lower atmospheric pressure in an aircraft cabin affects lymphatic competence and, thereby, may worsen or precipitate lymphedema (5). This inference is supported by the

Permission granted for single print for individual use.
Reproduction not permittion without permission of Journal LYMPHOLOGY

more extensive literature on the relationship between duration of air travel and the development of deep vein thrombosis (6).

There are very few published reports related specifically to air travel and lymphedema. In 1996, the Casley-Smiths (7), when reporting the results of a survey undertaken in 1993 of precipitating factors for lymphedema, noted that 27 from 490 respondents asserted that it had been initiated by air travel. An additional 67 participants reported worsening of the condition due to flying. In 1997, a report emanating from the National Breast Cancer Centre of Australia made the unsubstantiated claim that between 5 and 30% of women had their lymphedema precipitated by airline travel (8). More recently, Graham (9), from a retrospective survey of 287 women, concluded that air travel of less than 4.5-h duration represented a low risk for lymphedema. It is worth noting that this conclusion was apparently based upon the typical maximum duration of a domestic flight within Australia rather than objectively determined by risk analysis. Finally, Kilbreath and colleagues have reported, in abstract form only (10), that air travel elicited only minimal change in arm volume, as indicated by impedance ratio, in physically active women post breast cancer surgery while Swenson et al (11) have reported that air travel does not increase lymphedema risk.

We present a case report of a patient with mild lymphedema who, by virtue of her occupation, undertakes frequent air travel. Bioimpedance was used to measure the effect of air travel, both short- and long-haul, on her lymphedema status over a 12-month period.

CASE REPORT

The participant was a 55 year old woman presenting with unilateral lymphedema of her right dominant arm, secondary to breast cancer. She weighed 65 kg and was 162.5 cm tall with a body mass index of 24.6 kgm^{-2}, within the normal range. Her treatment for breast cancer occurred in January 2000 and comprised a mastectomy with reconstruction, as well as axillary dissection and node removal. All nodes were negative on testing. The participant was not treated with radio- or chemotherapy, but subsequently received Tamoxifen until 2005 and is now receiving Letrazole. Her lymphedema was clinically diagnosed by a medical practitioner in May 2000, 5 months following treatment for breast cancer. She reported that her lymphedema had not progressed beyond mild. Initially, she had perceived only slight swelling in her forearm, although at time of presentation she perceived mild swelling in her wrist and fingers. She had not received systematic treatment for lymphedema other than being provided with information on exercises to undertake; she reported that these exercises were not performed. She received occasional lymphatic drainage massage with the last one more than 8 months prior to the study. No active treatment was used during the year of study. A compression garment was generally worn on the affected limb on most long-haul (approximately 6 hours or longer) air flights, but not on other occasions.

We ascertained the participant's initial lymphedema status by quantitative bioimpedance measurement (XCA, ImpediMed Ltd., Brisbane, Australia). Her impedance ratio was 1.07 (L-Dex score 3.2), which was below the cut-off for detection of lymphedema in the dominant arm [1.139, (12)]. The participant was then provided with an XCA instrument and trained in its use. Specifically, she was instructed to clean the skin with an alcohol swab prior to attachment of the electrodes. The electrodes were positioned according to the manufacturer's directions to take advantage of the principle of equipotentials (13). The two drive electrodes were positioned at the base of the 3rd digit and dorsum of the foot; the two measurement electrodes were positioned at the wrist of each arm, using the ulnar styloid as a guide. Once the electrodes were in place, she positioned

Permission granted for single print for individual use.
Reproduction not permittion without permission of Journal LYMPHOLOGY

TABLE 1
Lymphedema Symptom Scores Pre- and Post- Air Travel. Values Presented as Mean Scores from All Assessment Occasions, with Range of Scores and Number of Occasions Symptoms Present

Symptom[1]	Pre-flight score	Post-flight score
Heaviness	0	0
Tightness	0	1 (1 occasion)
Pain	0	1 (1 occasion)
Temperature	0	0
Numbness	0	0
Aching	0.5 (range 1-3, 3 occasions)	1.1 (range1-4, 5 occasions)
Swelling	1.5 (range 1-2, 1 occasion)	2.2 (range1-7, 12 occasions)
Hardness	0	0
Lateral mobility	0	0
Vertical mobility	1 (1 occasion)	1 (1 occasion)

[1]Symptoms scored on an 11 point scale: 0 symptoms absent, 1-10 from slight to severe.

herself in a relaxed seated position with straight legs and the arms supported on an adjacent horizontal surface to collect the data.

She was asked to use the XCA to assess her lymphedema status prior to undertaking any air travel, i.e., as close as was practicable to departure. Lymphedema status was reassessed as soon as possible after arrival at her destination, i.e. within 90 minutes. Travel times and details were recorded in a travel diary. She was requested not to modify her normal flying habits but to record usage of a compression sleeve or other therapeutic measures used for her lymphedema. She transported her own luggage but always used luggage fitted with wheels. She was also required to complete a symptom checklist pre- and post-flight. This checklist, modified from that designed by Ridner (14), asked the subject to rate, on a 11-point scale, arm characteristics including feelings of heaviness, tightness, pain (tingling, burning etc.), aching, numbness and hardness, as well as perceived changes in swelling and range of motion. Assessment was conducted over a 12-month period during which the participant undertook a total of 20 airline flights. A series of control measurements were performed over a 10 day period immediately following return from a flight and while the participant resided at home and no additional air travel was undertaken. The subject's occupation was

Permission granted for single print for individual use.
Reproduction not permittion without permission of Journal LYMPHOLOGY

in the computer software industry and was exclusively sedentary other than travel.

RESULTS

The mean duration of flights was 3.5 hours with a range from 1 to 9 hours. The majority of flights (14 out of 20) were of 3 to 4 hour duration. Only two flights, of 7 and 9 hours, were greater than 5 h and could be classed as long haul flights. On no occasion did the participant report symptoms of heaviness, sensation of hot or cold, numbness or hardness. A minor change in range of motion, pain or arm tightness was reported on a single occasion (*Table 1*). Perception of aching and swelling of the affected arm were consistently reported and generally were reported to have worsened following air travel *(Table 1*), although concordance with the objective impedance measurement of swelling was relatively poor (*Figs. 1,2*). She also reported that her symptoms appeared to be related to behavior patterns on a flight and not simply duration. For example, she noted that swelling appeared to worsen if she was working (using a notebook computer) compared to when she was sleeping, sitting reading or watching in-flight entertainment or if she performed any of the recommended in-flight exercises.

The results of the quantitative assessment of lymphedema by impedance are presented in *Fig. 1*. A number of features are apparent. Firstly, her lymphedema worsened over time, although remaining in the mild category. Indeed, although she consistently perceived herself as having lymphedema, as indicated by the self-report of swelling, the impedance ratio was similar to control values up until December 22nd. Subsequently, the ratio exceeded control values, with these occasions coinciding with higher perceived swelling scores. Secondly, there was no clear relationship between lymphedema status and duration of flying time. Thirdly, the wearing of a compression garment appeared beneficial although data were limited to four occasions only. On each occasion that the sleeve was worn, the impedance ratio was either essentially unchanged or decreased from pre-flight values. On 10 out of 16 occasions when the sleeve was not worn, the ratio worsened following flying. No clear relationship between flight duration and lymphedema status, as indicated by the impedance ratio, was apparent.

Figure 2 presents the impedance ratios for 20 separate measurement times over a 10-day period immediately following return from an airline flight. The mean impedance ratio over this period was 1.147, just above the 3 SD range observed in the normal population. It is noteworthy, however, that the ratio fluctuated over this time being above this threshold on 10 (50%) occasions and below this value on an equal number of occasions.

DISCUSSION

This study provides preliminary evidence that air travel can exacerbate lymphedema. The participant flew on 20 occasions over a 12 month period, including 2 long haul flights. The mean impedance ratio increased over this period of time. Although the data were limited and contrary to previous suggestions, the compression sleeve appeared to be beneficial in controlling limb swelling.

For many women with lymphedema, air travel can pose a significant dilemma. Travel by air is commonplace and women with, or at risk of, lymphedema are likely to need or desire to travel by plane. Nevertheless, they are likely to have received advice that air travel poses a significant risk of precipitating or exacerbating lymphedema and should only be undertaken where it is otherwise unavoidable and after due consideration of these risks. It is surprising, however, that there is little or no evidence base for this advice. Casley-Smith and Casley-Smith in 1996 were among the first to warn women of the potential dangers of air travel (7). The basis for this advice was an uncontrolled

Permission granted for single print for individual use.
Reproduction not permittion without permission of Journal LYMPHOLOGY

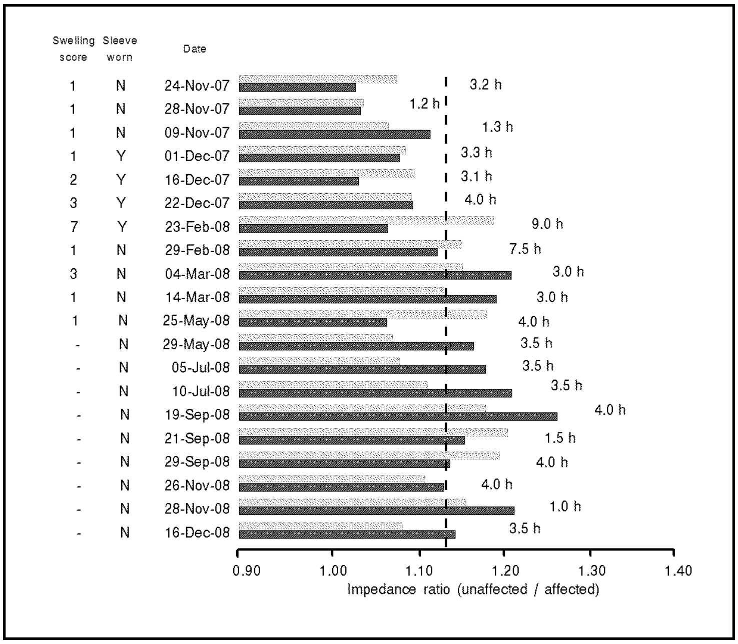

Fig. 1. Ratio of whole arm impedances before and after air travel and post-flight swelling score. Key: ❑ Pre-flight values; ■ Post-flight values; --- Detection threshold for lymphedema [mean + 3SD for control population (11)]; N/Y = Compression sleeve worn during flight; - No data.

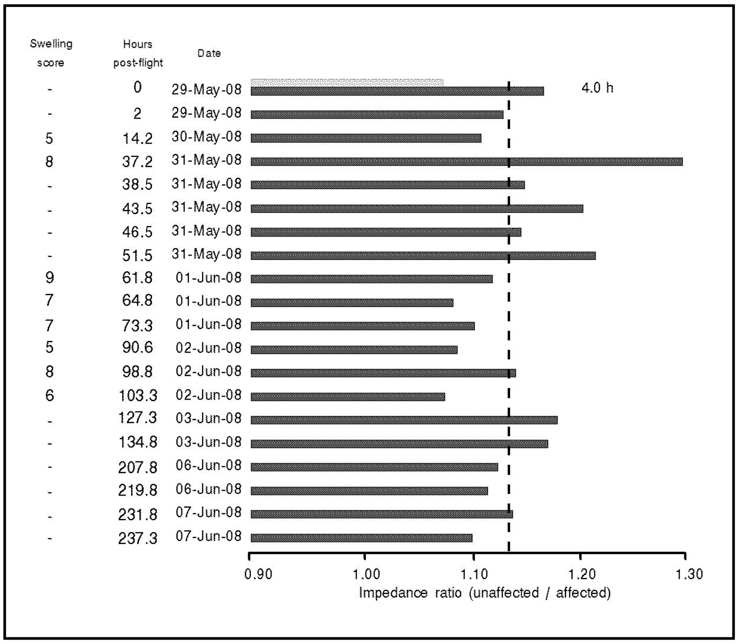

Fig. 2. Ratio of whole arm impedances immediately after and for 10-days following air travel. Cumulative hours from last flight are reported in column "hours post flight." Key: ❑ Pre-flight values; ■ Post-flight values; ---Detection threshold for lymphedema [mean + 3SD for control population (11)]; N/Y = Compression sleeve worn during flight; - No data.

Permission granted for single print for individual use.
Reproduction not permittion without permission of Journal LYMPHOLOGY

compilation of anecdotal experiences from questionnaire responses. In the decade since, there appears to have been only one other attempt to investigate the possible relationship between air travel and lymphedema. Graham, in 2002 (9), published the results of a retrospective survey of 293 breast cancer survivors, of whom 145 had flown in the previous 4 to 111 months. The key findings were that flights of up to 4.5-h duration were of low risk for lymphedema and that the use of compression devices may, counter-intuitively, be counter-productive.

The present single case study was not designed to provide definitive evidence of the risks, or otherwise, associated with air travel for women with lymphedema. Our aim was a proof of concept study as a pilot for prospective studies to investigate this relationship. A weakness of Graham's study was that the primary outcome measure was self-reported, perceived arm swelling recalled some months after the event. In the present study, we have used the objective measurement technique of bioimpedance analysis. This technique has been shown to have high sensitivity and specificity for increased extracellular fluid accumulation in early stage lymphedema (15) with high reliability of measurement. The impedance device used here has been specifically designed to be useable by the patient alone. The participant simply applies electrodes to the skin surface, connects the instrument leads and assumes a recumbent position. After a short time, to allow the participant to attain recumbency, the instrument records the limb impedance. Our volunteer in this study was able to make reproducible measurements after only a few minutes training. The instrument is small, approximately the size of a paperback book and is easily carried in hand luggage. This enabled impedance measurements to be made immediately prior to and following a flight. Participant compliance for recording data was high, with missing data for only two flights on 29th July and 19th September. In contrast, completion of the subjective assessment questionnaire, although a simple single page checklist, was found to be onerous with only sporadic completion during the last six months of the study.

Although our primary aim was to assess the feasibility of prospective studies of air travel, the results that we obtained from this single case study are of interest. The serial pre-flight measurements represent a time-course of progression of lymphedema in this participant. There is a suggestion that this, while remaining mild, was worsening over time. Since our volunteer undertakes frequent air travel, this raises the question of whether this progressive worsening may be exacerbated by the frequency of air travel; although acute effects of air travel are unclear. There is a suggestion that air travel may elicit an immediate increase in the impedance ratio, indicative of swelling, and that this may be, in part, ameliorated by the wearing of a compression sleeve. It should also be noted that the participant exhibited fluctuation in the impedance ratio, including a number of occasions (10) in which the 3 SD threshold for lymphedema was exceeded during non-flying times. Such fluctuation has been noted by others (16,17) and indicates that further studies of the effects of air travel upon lymphedema should include comparable non-flight periods of monitoring to determine baseline fluctuations in the condition.

It was interesting to note that the bioimpedance ratio was within normal limits at the commencement of this study. Our participant reported at that time, however, that she perceived swelling in the fingers and wrist and not necessarily in the forearm or upper arm. The placement of the impedance electrodes that was used was the placement recommended by the manufacturer and excludes the fingers and hand from measurement. In the future, for women in whom lymphedema is particularly focal to the hand, movement of the drive and measurement electrodes distal on the finger and hand would enable this region to be included.

Permission granted for single print for individual use.
Reproduction not permittion without permission of Journal LYMPHOLOGY

In conclusion, it is clear that further studies are required to provide the necessary evidence base for appropriate advice to be given to those at risk of lymphedema when contemplating air travel. Measurement of inter-limb impedance ratios can provide the necessary quantitative information and can be easily obtained by the participants themselves in prospective studies in the future.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the support and commitment of the participant in this study. The generous support of ImpediMed Ltd is also acknowledged for the loan of the impedance instrument.

REFERENCES

1. Weissleder, H, C Schuchhardt: Lymphedema of the arm following breast cancer therapy. In: Lymphedema Diagnosis and Therapy, Weissleder, H, C Schuchhardt (Eds.), Viavital Verlag Gmbh. Publ., Essen. 2008, 218-254.
2. Warren AG, H Brorson, LJ Borud, et al: Lymphedema: a comprehensive review. Ann. Plastic Surg. 59 (2007), 464-472.
3. Davis, BS: Lymphedema after breast cancer treatment: Earlier detection and treatment have improved chances of survival. Therefore, screening for lymphedema is an essential part of nursing practice. Am. J. Nurs. 101 (2001), 24AAAA-24DDDD.
4. National Health and Medical Research Council: Early breast cancer. A consumers guide, NHMRC, Sydney 1995.
5. Zuther, JE: *Lymphedema Management: Comprehensive Guide for Practitioners*, Georg Thieme Publ., New York (2005) 270p.
6. Philbrick, JT, Shumate, R, Siadaty, MS et al: Air travel and venous thromboembolism: A systematic review. J. Gen. Intern. Med. 22 (2007), 107-114.
7. Casley-Smith, JR, Casley-Smith, JR: Lymphedema initiated by aircraft flights. Aviat. Space Environ. Med. 67 (1996), 52-6.
8. Browning, C, Thomas and Associates: Lymphoedema: Prevalence, risk factors and management: A review of research. National Health and Medical Research Council, National Breast Cancer Centre report. Sydney, Australia (1997).
9. Graham, PH: Compression prophylaxis may increase the potential for flight-associated lymphoedema after breast cancer treatment. Breast. 11 (2002), 66-71
10. Kilbreath S, LC Ward, K Lane, et al: Effect of airplane travel on women treated for breast cancer. San Antonio Breast Cancer Symposium December 10-14 2008 San Antonio, TX, USA. p1119. Available at http://www.posters2view.com/sabcs08/numindex.php?range=10 Accessed 9th February 2009.
11. Swenson, KK, MJ Nissen, JW Leach, et al: Case-control study to evaluate predictors of lymphedema after breast cancer surgery. Oncol Nurs Forum 36 (2009), 185-193.
12. Cornish BH, M Chapman, C Hirst, et al: Early diagnosis of lymphedema using multiple frequency bioimpedance. Lymphology 34 (2001), 2-11.
13. Cornish, BH, A Jacobs, BJ Thomas, et al: Optimizing electrode sites for segmental bioimpedance measurements. Physiol Meas. 20 (1999), 241-250
14. Ridner, SH: Quality of life and a symptom cluster associated with breast cancer treatment-related lymphedema. Support Care Cancer 13 (2005), 904-911.
15. Ward, LC, SL Kilbreath, BH Cornish: Bioelectrical impedance analysis for early detection of lymphoedema. In: *Lymphedema Diagnosis and Therapy*. Weissleder, H, C Schuchhardt (Eds.), Viavital Verlag Gmbh Publ., Essen. 2008, 502-517.
16. Norman, SA, AR Localio, SL Potashnik, et al: Lymphedema in breast cancer survivors: Incidence, degree, time-course, treatment, and symptoms. J Clin Oncol. 27 (2009), 390-397.
17. Hayes, SC, M Janda, B Cornish, et al: Lymphedema following breast cancer: Incidence, risk factors, and effect on upper-body function. J Clin Oncol. 26 (2008), 3536-3542.

A/Prof Leigh Ward
School of Chemistry and Molecular Biosciences
Building #76
University of Queensland
St. Lucia
Brisbane, QLD 4072 Australia
Telephone: 61 7 3365 4633
Fax: 61 7 3365 4699
Email: l.ward@uq.edu.au

Permission granted for single print for individual use.
Reproduction not permittion without permission of Journal LYMPHOLOGY