# INFLUENCE OF REDUCED PRESSURE AND PHYSICAL RESTRAINTS ON PRE-MORTEM TISSUE SWELLING WHICH SOME TIMES RESULTS IN BLOOD CLOTS.

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#### Introduction and review of literature

Over 300 million passengers travel each year on long-distance flights (Brenner 2006). High risk passengers for DVT (deep venous thrombosis) include those having previous VTE (venous thromboembolism), known thrombophilia, major surgery with in previous 6 weeks, malignancy or family history of VTE, taking estrogen, varicose veins, older age, factor V Leiden mutant ion, joint problems, obesity, inherited or acquired hypercoagulability, exponentially with longer duration of travel (> 8 hour flight causes an increase), window or central seats, which suggest that that this problem is a multicausal disorder). As little as a 1 hour flight reduces venous return from legs and leads to local heamoconcentration and a 12 hours flight can lead to swelling and fluid retention which might be expected to confer a thrombosis risk (Watson, 2005). In spite of limited research there seems to be only a weak relationship between air travel and VTE but this relationship increases in flyers with increased risk factors and length of flight (Chee and Watson 2005, Arval and Al-Khaffat 2006). These authors also suggested that future studies are important as the public health concerns are significant. When an aircraft climbs usually to 1500 to 2499 meters cabin pressure the air pressure inside the cabin decreases and air and other gases expand by approximately 30%. These changes do not cause any problems where gas movement can take place freely, but may cause discomfort or damage when gas is trapped or restricted. Graduated compression stockings [GCS, hosiery; ankle has the greatest pressure, which gradually decreases up to the calf (Agu, et al., 1999)] are often utilized to prevent flight-related (flight associated, economy class syndrome, coach class thrombosis, flight thrombosis, and travelers thrombosis) thrombosis, was not explored until flight-related thrombosis was perceived as a preventable illness; however, their effectiveness in preventing flight-related thrombosis remains unresolved (Hsieh and Lee 2005). This problem is believed to be an interaction between limited leg space which can result in compression of veins, epically the popliteal vein (Belcaro et. al. 2003) and; therefore, reduced calf muscle pump efficiency (Chee and Watson 2006). To reduce flight deep vein thrombosis, the most commonly accepted method is the use of external-compression for the prophylaxis of flight-related thrombosis (Byrne 2001; Watson, 2005; Chee and Watson 2006). Other interventions recommendations often include standing and moving legs for 5-10 minutes/hour, avoid baggage between seats, and drinking water regularly (100-150 ml every hour). The results of studies on the effect of GCS ranges form no significant difference from the control to GCS were more effective than no GCS in preventing DVT regardless of the level of risk for DVT (Heish and Lee 2005). Several reports suggest that elastic stocking are advised for reducing the rate of DVT (Brenner, 2006; Scurr et al. 2001; Clarke et al. 2006). Stockings can alleviate edema which is common during long flights (Cesarone et al. 2003) which can be evaluated by lower leg. volume. Taking the total reported literature more studies reported a positive effect than no effect and none reported a negative effect of wearing GCS. No participants in any trials reported complaints or side effects from wearing below the knee GCS and they had good tolerability. A summary by Heish and Lee (2005) indicated that the application of below-knew GCS significantly decreased the occurrence of DVT but not SVT (other reports in the review indicate it is useful) in long-haul air travelers. Most healthy people when taking long flights experience some swelling of the legs. The air-lines recommend exercises and walking to help elevate this problem; however, is it well known that a closed container will expand when exposed

to reduced pressure. After surgery, elastic surgical hose are often used to retard leg swelling. A literature review by Agu, Hamilton, and Baker (1999) examined graduated compression stockings in terms of action, efficiency, and complications. and recommended that the below-knee rather than thigh-length stocking be used on the basis of equal effectiveness, improved use and patient tolerance, and lower cost.

#### Procedures

This research was conducted on 4 trips between the U.S. and China to see if surgical hose would be useful on long flights to retard leg swelling and lower leg volume, on two flights and reverse return flights between the US and China with was a total of 4 flights. Since this is a multi-causal disorder and with many of the causing factors unknown even to the flyers it is almost impossible to have an adequate control. To obtain a meaningful control, massive numbers (1,000's) of participants would be necessary in both the treatment and control groups. Therefore, it was decided to use one individual, described in detail (known risk factors, over 50, overweight, 6 foot 2 inches tall, 240 lbs, old right knee joint surgery), with one leg of each flight exceeding 8 hours, and isle seats were utilized, for both the treatment and the control. On the return flight the treatments were switched to the opposite leg. Foot, ankle and calf circumference were used as the dependent variable which should be highly correlated to leg volume. There will be some variations between departure and return flights caused by length of flights due to wind currents, small pressure differences due to altitude and cabin pressure but these variations are small compared to obtaining a adequate control to compare with the treatment group. Circumference measurements were taken every hour for the total flight including airport time. It would see reasonable to suggest that air shipment or transfer of animals to higher elevations might experience the same tissue swelling.

#### **Results and Discussion**

The order of swelling evaluation was foot, ankle, and calf. The elastic restraint retarded swelling at each location and the greatest improvement was in the reverse order.



# Figure 1 Foot, Columbus to/from Beijing Foot Columbus to Beijing

#### Figure 2 Ankle, Columbus to/from Beijing





13 PSI

12



### Time in hours Figure 3 Calf, Columbus to/ from Beijing

## Figure 4 Calf, Summary all four flights

Ground

14

The other 3 flights had similar variations but in all cases the GCS had reduce leg swelling as measured by conference.

Table 1 Statistics on all 4 flights			
	Foot – cm, Pr>F	Ankle – cm, Pr>F	Calf – cm,
			Pr>F
	Pressure	High	
Sock vs Hose	0.0220*	0.0224*	0.0080**
Trip 1,2,3,4 <sup>a</sup>	0.0221*	0.3724	0.1557
Leg R vs L <sup>b</sup>	0.2353	0.0314*	0.0347*
Combined	Pressure High, Foot+Ankle+Calf		
Sock vs Hose	0.0034**		
Trip 1,2,3,4 <sup>a</sup>	0.0638		
Leg, R vs L <sup>b</sup>	0.1765		
	Pressure	Low	
Sock vs Hose	0.0190*	0.0151*	0.0028**
Trip 1,2,3,4 <sup>a</sup>	0.4134	0.2502	0.1579
Leg, R vs L <sup>b</sup>	0.274	0.0489*	0.2937
Combined	Pressure Low, Foot+Ankle+Calf		
Sock vs Hose	0.0034**		

Trip 1,2,3,4 <sup>a</sup>	0.1429
Leg. R vs L <sup>b</sup>	0.2297

<sup>a</sup> 1 = Columbus-Beijing; 2 = Beijing-Columbus; 3 = Columbus-Changsha; 4 = Changsha-Columbus <sup>b</sup> R = Right Leg; L = Left Leg

\* Significance 5% level; \*\* Significance at 1% level.

Correlations of foot, ankle, calf and combination were all significant at the 5 or 1% level with two exceptions and they approached significance at the 0.07 level as would be expected.

In a second experiment the same individual using different treatment sequences were evaluated. This included a round trip flight from Columbus Ohio USA to Manila Philippines and a return flight. In the previous tests one leg had a restraint and the other leg (control) did not. It could be augured that in a closed system such as the body, the treatment could have influenced the control. So in the second experiment, on the outward flight both legs had compression hose (treatment) and on the inward flight both had socks (control). Two circumference measurements were made on the foot, ankle and calf area, at least one hour apart on all airport stops and flights measurements. The foot and ankle both on the ground and in the air showed little differences between the hose and the control (sock). However both on the ground and in the air the calf conferences were reduced for the calf area by the compression hose.

**In summary** this research suggest that GCS statistically reduces edema on long distance air flights for an individual with medium risk factors.

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