Sleep and Hospital Noise: Achieving Noise Reduction with a Novel System for Mobility and DVT Prophylaxis

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Karen K. Giuliano, PhD, RN, FAAN, MBA[1]; Rachel Pozzar; PhD, RN [2]; Jeff Schwegman [3]

Associate Professor (Joint), University of Massachusetts Amherst, College of Nursing & Institute for Applied Life Sciences, Amherst MA[1]; Postdoctoral Fellow, Dana-Farber Cancer Institute, Boston MA [2]; RF Health, Fishers IN [3]

Introduction

In the hospital setting nighttime noise levels frequently exceed the **maximum 40 dBA** thresholds recommended by the World Health Organization (WHO) and Environmental Protection Agency (EPA). Studies have documented hospital rooms ranging from 48-79 dBA with peak levels frequently exceeding 100 dBA. Excessive hospital noise is associated with disrupted sleep, impaired immune function, impaired mentation, increased risk of delirium, and increased mortality.

Medical equipment is a major contributor to hospital noise. Intermittent pneumatic compression (IPC) devices are commonly used in the acute care setting to prevent venous thromboembolism among hospitalized patients. All IPCs require the use of air pumps and plastic sleeves that inflate once/minute with optimal use at 18-22 hours per day. Yet little is known about the extent to which IPC use contributes to hospital noise and sleep disruption.

Aims

The Movement and Compressions™ (MAC) System by Recovery Force (RF) Health was designed to provide a novel way of providing mechanical compression without the use of pneumatic pumps or bladders, to achieve improved performance, comfort, and noise reduction.

Aim 1. Design the RF Health MAC™ System functional prototype to operate with less overall noise than three commonly used IPC devices: the VenaFlow Elite®, the Kendall SCD™ 700 Compression System™, and the ArjoHuntleigh Flowtron™.

Aim 2. Based on the findings of the initial acoustic testing results, optimize the MAC System for additional sound reduction and conduct follow-up sound measurements on the finalized version.

Contact

Karen K. Giuliano, PhD, RN, FAAN, MBA
kkgiuliano@umass.edu

Materials & Methods

1. All acoustic testing was conducted in the sound laboratory at the independent acoustic testing firm Indy Acoustic Research, LLC in Indianapolis, Indiana.
2. The first round of acoustic testing was completed on October 18, 2018 and included the VenaFlow Elite System and the Kendall SCD Compression System.
3. During acoustic testing, the IPC sleeves of the model being tested were placed on the center of a 30-inch x 60-inch tabletop. The powered IPC pump was placed on top of a foam block at one end of the tabletop simulating the placement of these pumps in hospital rooms at the foot of the bed, while a microphone was placed at the other end of the tabletop (Figure 1) to simulate the head of the patient's bed.
4. Room noise, equipment noise, and sound frequency were measured using a Bruel and Kjaer 4190 laboratory measurement microphone positioned at 30 cm x 40 cm x 50 cm from the end of the tabletop.
5. A set of three measurements were taken on each device.
6. Once the development of the MAC System functional prototype was completed, acoustic tests were conducted on February 13, 2019.
7. The same testing protocol was used, but since the MAC System has an integrated strap and motor, the whole system was placed at the end of the tabletop (Figure 2).
8. The RF Health MAC System underwent additional design changes, and sound testing on the final design was repeated on June 18, 2020.
9. The ArjoHuntleigh Flowtron was added to the June 18, 2020 round of testing.
10. The final step was to measure noise duration per cycle with each device. This testing was completed in the RF Health lab on June 30, 2020. (Table 2)

Figure 1

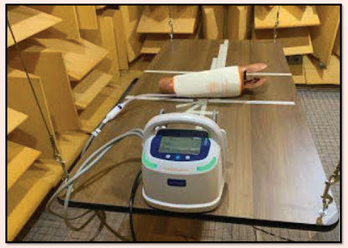
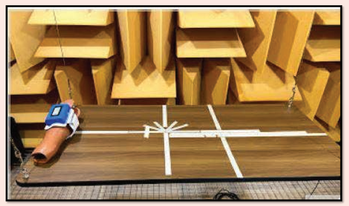


Figure 2



Results

Results for attributable sound and sound duration/cycle for each device on all testing days are provided on Table 1.

Table 1

Test Run	Attributable sound Intensity (dBA)
VenaFlow Elite®: October 18, 2018	
Run 1	48.1
Run 2	48.5
Run 3	48.2
Mean	**48.3**
SD	**0.21**
Kendall SCD™: October 18, 2018	
Run 1	44.8
Run 2	43.8
Run 3	43.9
Mean	**44.2**
SD	**0.55**
RF Health MAC™ System: February 13, 2019	
Run 1	32.6
Run 2	37.8
Run 3	31.1
Mean	**33.8**
SD	**3.5**
ArjoHuntleigh™ System: June 18, 2020	
Run 1	40.2
Run 2	43.7
Run 3	37.3
Mean	**40.5**
SD	**3.1**
RF Health MAC™ System: June 18, 2020	
Run 1	23.3
Run 2	23.7
Run 3	22.5
Mean	**23.2**
SD	**0.62**

Table 2

Inflation Time (seconds)		Compression Time (Seconds)		Deflation Time (Seconds)		Total Cycle Time (Seconds)	Sound Duration Per Day (Max)*
Left	Right	Left	Right	Left	Right	Total	Total
VenaFlow Elite®							
1	1	6	6	8	8	30	12 hours
Kendall SCD®							
11	11	0	0	11	11	44	17.6 hours
ArjoHuntleigh™ System							
6	6	8	8	6	6	40	16 hours
Compression Time (seconds)		**Hold Time (Seconds)**		**Compression Release Time (Seconds)**		**Total Cycle Time per Minute (Seconds)**	**Sound Duration Per Day (Max)***
Left	Right	Left	Right	Left	Right	Total	Total
RF Health MAC™ System							
1	1	1	1	2	2	8	3.2 hours

*All measurements were rounded up to the nearest second and total cycle time/sound disruption maximum assumes asynchronous operation of right and left legs.

Discussion

- In the first round of testing, the mean sound intensity directly attributable to the VenaFlow Elite System, the Kendall SCD 700 Compression System, and the RF Health MAC System was 48.3, 44.2, and 33.8 dBA, respectively, validating the MAC System as the quietest of the three devices.
- With additional design changes, the MAC System was reduced to a mean sound intensity of 23.2 dBA with very low (SD=0.62) variability in individual measurements and significantly quieter than the ArjoHuntleigh Flowtron tested with a mean of 40.5 dBA.
- Comparatively, the attributable sound intensity for the RF Health MAC System was less than than the VenaFlow Elite System, the Kendall SCD700 and the ArjoHuntleigh Flowtron by 52%, 47%, and 42% respectively.
- The duration of sound per day with the RF Health MAC System (3.2 hrs) was substantially less than the VenaFlow Elite System (12 hrs), the Kendall SCD700 (17.6 hrs) and the ArjoHuntleigh Flowtron (16 hrs).

Conclusions/Clinical Implications

- The findings of this work provide insights into the noise levels produced by three commonly used intermittent pneumatic compression (IPC) devices found in hospitals.
- The RF Health MAC was the only mechanical prophylaxis system that achieved a total noise level that did not exceed the WHO & EPA recommended thresholds (40 dBA) for nighttime hospital noise.
- With the American College of Chest Physician Guidelines for mechanical compression for DVT prevention of 18-22 hours/day, the differences in sound duration between the devices are a likely factor in adherence to prescribed use.
- Improvements in medical device design have the potential to significantly reduce noise in the hospital environment. Noise reduction is important to promote the patient's sleep patterns and contribute to improved patient outcomes.
- Further research is needed to explore associations between medical device types/models, impact of noise levels with recovery/patient satisfaction, and total duration of sleep disturbance during an overnight hospital stay.

References

1. Busch-Vishniac IJ, West JE, Barnhill C, Hunter T, Orellana D, Chivukula R. Noise levels in Johns Hopkins Hospital. *The Journal of the Acoustical Society of America.* 2005;118(6):3629.
2. Jones C, Dawson D. Eye masks and earplugs improve patient's perception of sleep. *Nurs Crit Care.* 2012;17(5):247-254.
3. Kahn, S.R., Lim, W., Dunn, A.S., Cushman, M., Dentali, F., Akl, E.A., Cook, D.J., Balekian, A.A., Klein, R.C., Le, H. and Schulman, S., 2012. Prevention of VTE in nonsurgical patients: antithrombotic therapy and prevention of thrombosis: American College of Chest Physicians evidence-based clinical practice guidelines. *Chest*, *141*(2), pp.e195S-e226S.
4. Pope DS, Gallun FJ, Kampel S. Effect of hospital noise on patients' ability to hear, understand, and recall speech. *Research in Nursing & Health.* 2013;36(3):228-241.
5. Xie H, Kang J, Mills GH. Clinical review: The impact of noise on patients' sleep and the effectiveness of noise reduction strategies in intensive care units. *Crit Care.* 2009;13(2):208-208.