Towards the Development of an Alternating Pressure Overlay for the Treatment of Pressure Ulcers Using Miniaturized Air Cells

Authors: Malindu Ehelagastenna¹, Ishan Sumanasekara¹, Hishan Wickramasinghe¹, Indrajith D. Nissanka¹,* , Gayani K. Nandasiri²,*

1 Department of Mechanical Engineering, Faculty of Engineering, University of Moratuwa, Sri Lanka;
2 Department of Textile and Clothing Technology, Faculty of Engineering, University of Moratuwa, Sri Lanka
* Correspondence: gayanin@uom.lk (G.K.N); nissankai@uom.lk (I.D.N)
PRESSURE ULCERS?

- Skin Deformity

- Application of prolonged pressure on the skin which compresses the blood vessels that supply oxygen and vital nutrients to the skin.

- More prominent in bony areas

GLOBAL IMPACT

- Annual total treatment cost of pressure ulcers
  - UK is £1.4–2.1 billion (which is around 4% of total NHS expenditure)
  - US is $18.5 billion to the health system

- Death of 60,000 persons in the US (2019)

---

IF NOT TREATED PROPERLY....

**STAGE 1**
- Skin discoloration
  - Red
  - Blue
  - Purple
  - Black

**STAGE 2**
- Some skin loss or damage involving the top-most skin layers

**STAGE 3**
- Necrosis (death) or damage to the skin
  - Limited to the skin layers

**STAGE 4**
- The necrosis of the skin goes down towards the deep layers which might even lead up to the bone through the tendon and joints
  - Lead to amputations (42%) and then even to death

European Pressure Ulcer Advisory Panel
CURRENT TREATMENT METHODS

**SUPPORT SURFACES** –

- Functions -
  - Reducing or Redistribution of Pressure
  - Reduce friction and shear forces

- Factors selecting a support surface –
  - Stage of the pressure ulcer
  - Cost of the device ($100 - $40,000)
  - Patient’s Comfort
  - Durability

**NUTRITION**

**DRESSINGS(ALGENATE AND HYDROCOLLOID) AND TOPICAL AGENTS**

**CARE GIVING**

SUPPORT SURFACES

- **REACTIVE SUPPORT SURFACES**

  - **Reduction** of pressure

  - Foam mattress, Water mattress, Gel mattress

  - Immersion or Envelopment of the body –
    Body weight distributed over a larger surface area

  - Reduction of pressure –
    **Not sufficient** to stop the blockage of blood circulation

ACTIVE (ALTERNATING PRESSURE) SUPPORT SURFACES

• Pressure **Redistribution** –
  Areas of the body experience zero pressure in different cycle times

• Usually cycle time – 4 to 6 times an hour

• Added advantages –
  Tissue perfusion and removal of toxic metabolites
  Increased Lymphatic Drainage
  Prevention of the patient being slipped down

• **European Pressure Ulcer Advisory Panel**
  Recommend to patients who cannot reposition regularly

• According **WHO**
  **Reduce** risk of pressure ulcers specially of high risk patients

• **Better pay back** in comparison with standard hospital beds

---

AIM AND OBJECTIVES

• AIM
   To develop a control system to achieve high resolution, self-controlling, mobile support surface for the treatment of pressure ulcers

• Objectives
  ✓ To develop the effective alternating pressure formulation method for pressure ulcer treatment
  ✓ To design a control system for regulating the pressure of the support surface, providing self-controllability
METHOD

• Proposed system consist with two parts

Alternating pressure overlay

Alternating Layer

Static Layer

Control system of the pressure alternation

• Control the stiffness of the overlay
• Identify the localized high pressure zones
• Initiate alternating pressure patterns
METHOD

• Basic Functions of The Pressure Alternating

Modes of Overlay

- Sleep mode
- Alternating mode
- Auto-firm mode
RESULTS AND DISCUSSION

Basic overview of the control system
Pressure Pattern

- Randomised air cell array
- Higher pressure localized zones will be actuated
- 1-in -4 cycle
- 75% of patient’s body to be comfortably support on inflated air cells
- Cycle time: 10, 15, 20 min

Inflated air cells  Deflated air cells
Pneumatic Diagram Of The Control System

a. - Pump
b. - Air Filter
c. - Variable pressure control valve
d. - Non-return valve
e. - Static cell group
f. - CPR valve
g. - Exhaust-silencer
h₁-h₄. - Individual deflatable set of bladders in zone 1
j₁/j₂. - N/C Solenoid operated 3/3 valve
k. - Solenoid operated variable pressure relief valve
s₁-s₄. - Back pressure sensors
CONCLUSION

• Ongoing research of designing and development of a pressure alternating overlay
• Cell-on-cell design to avoid bottoming out while providing a high-resolution pressure pattern
• Three modes of actuation: Sleep mode, Alternating mode, Auto-firm mode
• Flexibility to adapt the stiffness of the overlay with patient’s body weight
• Real-time localized high pressure zone identification by monitoring back pressure
• 1-in-4 alternating cycle for comfortable weight distribution on inflated air cells
ACKNOWLEDGEMENTS

• The authors would like to thank the University of Moratuwa, Sri Lanka for the support given in completing this paper and providing facilities to conduct the research.

CONTACT INFORMATION

• Malindu Ehelagastenna: malindu.ehala@gmail.com
• Ishan Sumanasekara: ishansumanasekara@gmail.com
• Hishan Wickramasinghe: hishanw112@gmail.com
• Indrajith D. Nissanka: nissankai@uom.lk
• Gayani K. Nandasiri: gayanin@uom.lk
THANK YOU