PREVENTING DEEP VEIN THROMBOSIS USING A WEARABLE SEQUENTIAL COMPRESSION DEVICE

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**Deep Vein Thrombosis**
- Deep Vein thrombosis (DVT) occurs when a blood clot forms in the deep veins\(^1\).
- DVT affects pre-operative, post-operative, and bed-ridden patients that suffer from a lack of movement/poor circulation.
- If untreated, clots can break apart, resulting in a pulmonary embolism (PE).
- Existing sequential compression devices (SCDs) lack compression strength, are heavy, and restrict patient mobility.

**Design Specifications**
- The device shall:
  - Apply 80 mmHg of pressure
  - Be breathable, non-irritable, and adjustable
  - Weigh < 5 lbs
  - Have replaceable batteries
  - Permit ankle movements and patient mobility

**Hardware**
- **ESP32 Feather Microcontroller**
  - Need a centralized, efficient, yet small microcontroller which can handle many inputs and outputs
  - The ESP32 Feather is a relatively small microcontroller that can be implementable to a PCB\(^2\)
  - It features a dual-core processor

**Power Design**
- Need an easily accessible and rechargeable battery that can last at least 3+ hours while not being too heavy.
- Integrated 9V 600mAh Li battery for appropriate power rating, and lightest solution.
- Implemented a DC/DC converter which takes in 9V input and output a stable 5V, which would feed into rest of system.

**Inflation Mechanism:**
- **Sequential ascending inflation** of compression bladders (distal to proximal).
- Airflow to/from bladders regulated by pump-sensor-valve system.

**Compression Bladder Fabrication:**
- Decreased number of compression bladders from 8 → 6
  - Reduced total weight with smaller manifold and fewer valves.
- Physically and chemically bonded vinyl to form airtight bladders and integrate silicone tubing.
  - Inner seal: epoxy (chemical)
  - Outer seal: heat seal and heat shrink tape (physical)

**Inflation Sequencing & Design**
- Challenge: Inflation and deflation in the initial prototype operated too slowly, potentially allowing backflow of blood.

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**Motor and Valves**
- Valves need to withstand a high flow rate and high pressure\(^3\):
  - 3-way universal valve
  - Power consumptions of 0.5 Watts with 5 V input
  - Supplying valve with motor with 3 L/M flow rate

**Results & Future Work**
- **Results:**
  - Designed 6-bladder SCD, with 80 mmHg pressure settings.
  - One inflation cycle completes in 5 seconds.
  - Device is portable, enhancing patient mobility.
  - Device fits calf size up to 21" circumference.
  - Battery life of 3.5 hours

- **Future Work:**
  - Recycle air between compression bladders to reduce power consumption.
  - Increase battery life to 6-8 hours.
  - Create a monitor to display pressure applied.
  - Design attachment extenders to accommodate for a wider range of limb sizes.
  - Write a user manual.

**References & Acknowledgments**
- [1] Penn Medicine - Deep Vein Thrombosis