An Automatic Charting System for Surgical Drain Output

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Needs Statement & Background

Clinical need: There is a need for a way to automatically characterize and chart surgical drain output of patients postoperatively to increase the accuracy of reported drain output.

Surgical drain output affects decisions regarding post-operative care. The quality of drain output can indicate the development of post-operative complications (bleeding, gastrointestinal leaks, etc.). Criteria that affects these decisions include: 24-hr output, fluid color, and drain location and type.

Tracking this data in the inpatient setting can be unreliable. Charting compliance failures can lead to increased financial costs associated with missed post-operative complications. Additionally, the charting process can cost the nursing team time. Charting failures can incur costs to both the hospital and the patient, as the decision to remove drains may ultimately have consequences on a patient's length of stay as well as patient outcomes.

The main pain points derived from our informal nursing staff interviews include increased compliance, increased ease of inputting charting data in EMR, and a better way of managing multiple surgical drains.

Market Analysis

A total of 10 million inpatient surgeries happen in the US every year.[1] The global surgical drain market was estimated to be **75.5 million** drains sold in 2020 and is projected to reach **95.5 million** in 2030.[2] The target market segment is active drains used in the inpatient setting, which has a yearly value of $**284.15 million**,[3] shown below in *Figure 1*.

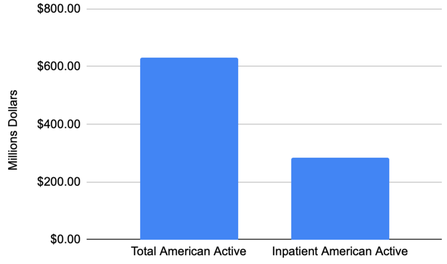


Figure 1: Total vs. Inpatient American Active Drain Market

For a midsize hospital (approx. 1,000 beds), assuming an average charting time of 3 minutes, it was calculated that total labor cost to chart surgical drainage over one year is **$41,790.75**. This cost incurred to hospitals does not include potential cost of extended stay due to delayed surgical drain removal or delayed identification of surgical complications as related to drain output. This modest estimate demonstrates the potential benefit of a cost-effective solution on hospital stakeholders from a financial perspective.

Design Considerations

There are multiple possible methods for measurement of surgical drain output, including analyzing fluid flow, volume, or weight.

The main requirements needed of output measurement incorporate the following:

- Contactless, reusable
- No movable parts
- Continuous level measurement
- Minimal components
- Reliable measurement not impacted by movement/shifting of volume around container
- Reliable measurement not impacted by composition/character of drainage output (pH, temperature, electrolytes)

Methods that were considered include; ultrasonic flow sensor, hall effect flow sensor, thermal flow sensor, optical level sensor conductivity level sensor, radar sensor, float level transmitter, and load cells.

Solution

Our solution utilizes a form of point level measurement that can effectively and indirectly measure drain volume. Our initial device design directly attaches to the exterior of a surgical drain bulb, as shown in *Figure 2*.

The external device can be used to measure a quantitative variable that we will refer to in "Device Units". This measurement can be used to extrapolate the volume of a given container, for example a surgical drain bulb.

The components of our proposed level sensing system can be an external, partly reusable and relatively cheap way to measure drain volume. This proposed solution can be applied to both active and passive drains.

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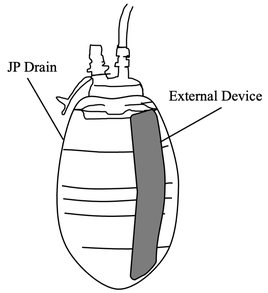


Figure 2: Basic Point Level Measurement Device Design

Preliminary Results

Initial trials using a 100 mL plastic beaker were run to validate our proposed method of volume measurement. Data was collected using both 0.9% saline solution and tap water in 10 mL increments. For every 10 mL of either saline or tap water added to the beaker, an additional **1.26 "Device Units"** were measured relative to baseline; indicating a linear relationship between "Device Units" and volume, as illustrated in *Figure 3*.

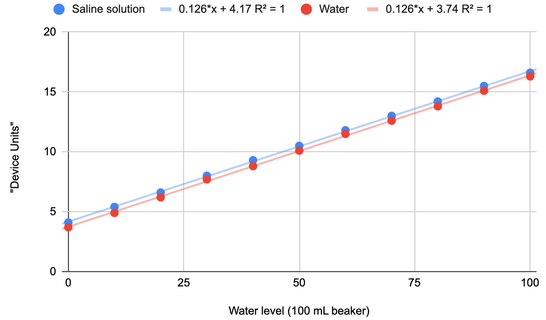


Figure 3: Device Units vs Volume (mL) of Saline Solution and Water

The slope of the trendlines for saline and water are identical, however the y-intercept varied between trials. This discrepancy is likely due to adjustments of external components of the device between trials and not related to the presence of salt in the water. A way to account for this difference may be to include a reference sensor or ensuring to calibrate initial measurements at 0 mL.

Future Directions

An initial goal includes need confirmation with a study that measures the following dependent variables: compliance with drain emptying and accuracy of output charted.

Future development of our prototype includes allowing remote access of the collected data. Adding features that include extrapolation of drain rate and measurement of color would be valuable in the inpatient setting.

References & Acknowledgements

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