An Insight into ICP Monitoring of Patients with Hydrocephalus using Data Science Approach

H. Alsmadi[1], A. J. Aljaaf[1,2], A. Hussain[1], J. Mutafina[3], R. Al-Jumeily[4], T. Baker[1,] and C. Mallucci[5]
[1]Facuilty of Enginnering and Technology, LJMU, UK
h.b.Alsmadi@2016.ljmu.ac.uk, {a.hussien, t.m.shamsa}@ljmu.ac.uk
[2]Center of Computer, University of Anbar, Iraq
a.j.aljaaf@uoanbar.edu.iq
[3]Kazan Federal University, Russia
dnmustafina@kpfu.ru
[4]Belveder British School, Abu Dhabi, UAE
r.aljumeily@belvederbritishschool.com
[5]Alder Hey Children's Hospital, Liverpool, UK
cmallucci@me.com

***Abstract*—Intracranial pressure (ICP) could be an indicator of a neurological disorder known as hydrocephalus, which is currently managed by shunting procedure. This paper investigates the current advances of shunting valves and provides an overview of ICP readings interpretation from a medical point of view with reference to Alder Hey hospital in Liverpool, UK. Moreover, this paper helps to express ICP readings using advanced data science approach and prepares for implementing intelligent approaches as an alternative pathway to improve the use of ICP within the current medical system. It is assumed that this paper would help specialists and non-specialists in an informative way to comprehend ICP readings. It also allows combining ICP reading with other parameters to derive a proper action with respect to patients with hydrocephalus.**

Keywords—Intracranial Pressure, Valve, Monitoring, Hydrocephalus.

I. INTRODUCTION

Hydrocephalus is understood to be a complicated neurological disorder caused by "the dynamic imbalance between the production and absorption of cerebrospinal fluid (CSF) leading to enlarged vortices", or stated more explicitly, a condition that attributed to the increased CSF amount in the ventricles caused by disruption in flow, absorption, or formation [1, 2]. Hydrocephalus can arise at any age, even before birth [3]. Some statistical estimates have shown that one out of every five hundred children are affected by hydrocephalus and this rate is most likely on the rise [4].

ICP is monitored from 10 to 15 minutes at different times. A significantly high ICP for at least 10 to 15 minutes raises concern, where then a look at other associated symptoms is essential. Doctors could look at a patient's status to find out whether he prefers to lie down or find it difficult to wake up.

In general, the telemetric devices consist of three main parts namely the passive implant, the active antenna, and the storage monitor. Usually, after planting the shunt, patients have raumedic device to record ICP readings continuously until ensuring that the patient's ICP is stable. CT scan could be performed when patients are acuity unwell, symptomatic, and the ICP is high. Many symptoms would associate with abnormally high or low pressure including, irritability, weakness, drowsiness, nausea, fever, and double vision.

This paper provides insight into ICP monitoring of patients with hydrocephalus in terms of readings and specifications, as well as discusses different types of valves adjustments in reference to Alder Hey Children's Hospital in Liverpool, UK. This paper is organised as follows, section 2 demonstrates the adjustment of two well-known shunt valves namely Miethke and Hakim. Section 3 explains the specifications of ICP readings. In section 4, we implement a data science approach to improve the representation of ICP for intelligent feature extraction method. Section 5 Explain the manual observation procedure by clinicians. Whiles, section 6 concludes this study and suggests our future direction.

II. SHUNT VALVES

A. *Miethke valve*

Recently Meithke group has improved shunt valves by moving from differential pressure (DP) technique to adjustable units, which is able to adjust pressure level according to clinical conditions. Anti-siphon devices and gravitational valves (G valves) represent the comparison of the rising hydrostatic pressure column when the patient is in the upright position.

The implanted internal sensor reservoir is the first long-lasting implantable pressure measuring unite within a shunt system. It is attached into a reservoir for a ventricular drainage system and conveys pressure values using non-invasive, telemetry techniques through a display unit [5].

B. *Hakim valve*

Codman Hakim programmable valve is one of the most popular valves for hydrocephalus shunt. It allows for customised treatment regimens via the use of an externally applied and codified magnetic field [6].

III. ICP READINGS

Figure 1 shows a sample of ICP readings extracted using the raumedic ICP device. The graph shows that the patient has normal ICP that vary from 0 cm H_2O to 20 cm H_2O. Figure 2 shows ICP readings that vary from -2 cm H_2O to -13 cm H_2O, which indicates that the patient has over drainage.

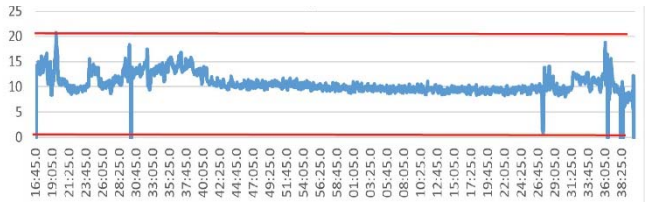

Fig. 1. ICP signals within the normal range

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Fig. 2. ICP signals with readings below the normal range

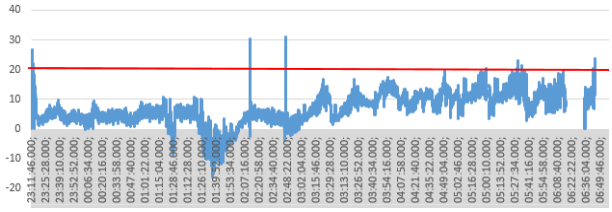

Fig. 3. ICP signals with readings above the normal range

As the readings are below 0 cm H_2O, it prefers to patients in a laying down position feeling more comfortable. Figure 3 shows normal ICP signals with some high readings that sometimes goes above 20 cm H_2O.

IV. Feature Extraction and Selection

The first step of building Building information system from data to be applied in machine learning is to examine the characteristics of the data, which is commonly known as a data processing stage [7]. Figure 4 illustrates a flow chart representing the steps that been followed.

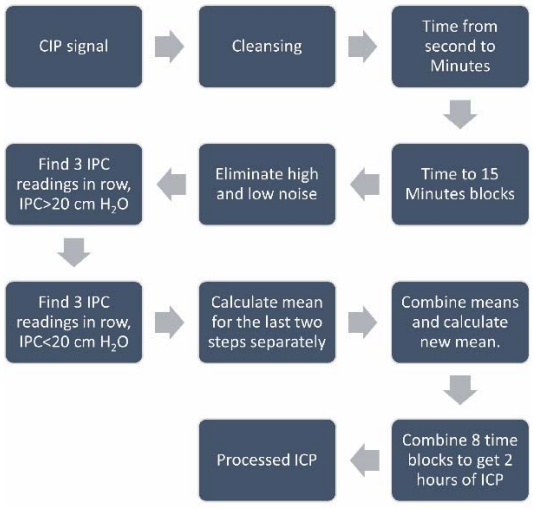

Fig.4. Feature selection of an ICP signal.

V. Manual Observation Procedure by Clinicians

Based on our observations as well as the knowledge from domain experts in Alder Hey Hospital, we have come up with a basic principle for automatic observation or monitoring of patients with hydrocephalus. This procedure is presented in different flowcharts and figure 5 shows sample of these flowcharts. It is considered as the best practice to follow in managing such patients, where each one of these flowcharts represents some sort of action to be taken according to four parameters. These parameters are ICP readings, associated symptoms, shunt functions, and intercurrent illness. Specialists use such parameters as ground truth for their decisions.

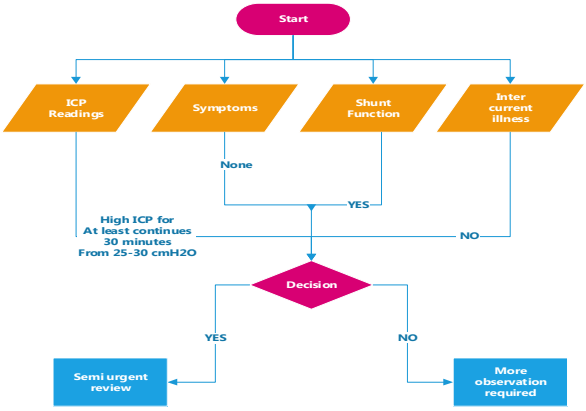

Fig.5. Actions to be taken based on conditions

VI. Discussion and Future Work

In this study, we provide insights into ICP reading interpretation and background information on current shunting system for patients with hydrocephalus. We have applied data science approach to process and extract features from ICP readings. This was done with the aim of having an automatic observation procedure to consider when assessing patients with hydrocephalus, while our future goal would be to implement advanced machine learning for ICP processing and assessment. Thus, understanding ICP readings along with considering the essential parameters such as symptoms and shunt function would be the first step toward a more sophisticated intelligent system to manage ICP and patients with hydrocephalus.

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