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FHIR based System for Managing Physiological Parameters of Brain Dead Patients

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Abstract--- *Considering scarcity of human organ for transplantation, it is important to make sure that, every available organ is transplanted without wasting it. It gives better life for someone who is waiting for it. Organ from brain-dead patient is a major source of organs. So, it is important to monitor and maintain the health of the organ of a brain-dead patient while his heart is still beating. A centralized system to monitor and alert about the health of the organ is best suited solution to make sure organ is well kept till it is transplanted. This paper gives an approach based on Health Level 7,Fast Healthcare Interoperability Resources (HL7 FHIR) for such a system which is centralized and uses new age technologies to make sure physiological parameters of organ from brain dead patient are monitored automatically and alerts are provided to the care givers in case there is any deviation of the monitored parameters.*

Keywords--- *FHIR, HL7, IOT, AI.*

I. INTRODUCTION

Almost half a million people die in India due to unavailability of human organs for transplantation. The organ donors in India is very small and about 0.8 person per million. So, it is very important to make sure that, each available organ is utilized and not wasted.

A significant portion of the available organ comes from brain dead patients. Organ donation after declaration of brain death (neurological death) represents the only source of thoracic organs (hearts and lungs) suitable for transplantation. It is, therefore, increasingly important to actively manage brain-dead donors. Management of cardiovascular parameters and pulmonary parameters are vital for the overall health of the organ and improves the success rate of organ transplantation.

Management of the physiological parameters of the brain- dead patient is challenging since the care providers are more focused in saving the critically ill patients who has some survival chances than monitoring and treating brain dead patients. But with the recent development in technology such as medical -Internet Of Things (IOT) and centralized cloud- based-Artificial Intelligence (AI), it is possible to provide constant monitoring of the physiological parameters of the brain-dead patient and make sure proper alert system is established for making corrective measures in case of any deviation of the physiological parameters.

This paper describes such an automatic approach to monitor the physiological parameters of the brain-dead donor and alert the care giver incase of any correction required. The approach make use of FHIR based medical device connectivity, medical IOT and AI concepts.

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II. SYSTEM COMPONENTS

A. FHIR based Connectivity

FHIR is a very promising connectivity option for the communication of medical parameters across the medical system. It is easy to implement, as there are ready made libraries and framework available to develop the required system. HL7 FHIR uses web technologies such as http and xml to communicate data across the systems.

B. Cloud Hosted AI based Medical Algorithms

The AI and Machine learning concept can be applied effectively for predicting the health of the organ using the physiological parameters of the brain-dead patient. Hosting these algorithms on cloud provides the solution available for multiple care providers/hospitals

C. Hospital Connector

The data generated in the hospital needs to be routed out of the hospital to provide a centralized algorithm support. Hospital network typically deploy strong firewall concepts to block all the incoming communication channel and allows only https outgoing channels. Special consideration needs to be taken to establish connection to the cloud hosted algorithm module.

D. Alert Module

Alert module plays a significant role in the overall system. In case of deviation of the physiological parameters the alert system takes the role of informer and inform the care giver about the deviation and urgency of corrective measure.

III. SYSTEM MODEL

A system model to establish automatic monitoring of the physiological parameter is given below. The model also has components to alert the care givers, incase of any deviation in the physiological parameter of the brain-dead patient.

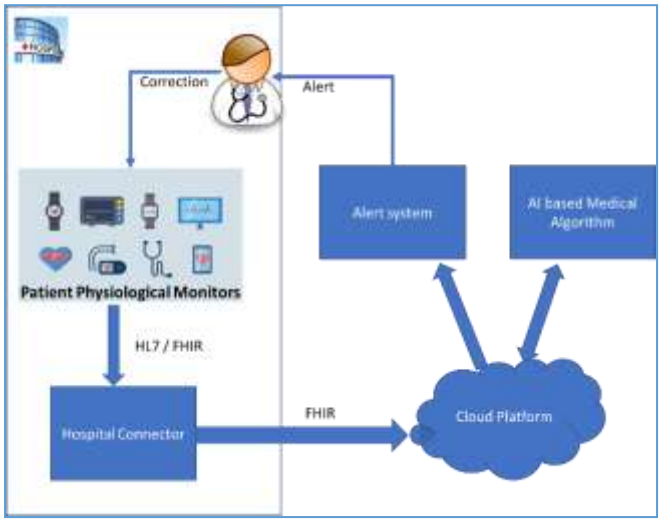

Fig. 1: Suggested System Model

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A. Logical Workflow

The physiological parameters of the brain-dead patients are collected using various medical devices connected to the patient. The data thus collected are packaged using hospital collector module and communicated to the cloud platform. The data communication between device, hospital collector and cloud platform are all through FHIR protocol. The cloud platform routes the data to the medical algorithm module. Algorithm module compares the data against the predefined parameter range. Any consistent deviation shall be informed to the alert system for further communication to the care giver.

It is important that system shall not generate alert for the false deviation which happens due to connection disruption between the device and patient (e.g.: ecg cable disconnection). The AI module is designed to handle these situation.

B. Physiological Parameter Range

There are various physiological parameters which needs to be measured and monitored for the benefit of getting a healthy organ from a brain dead patient. Some of the key parameters which needs to be maintained and their targeted range are given in the table below.

Table I: Physiological Paramters and Targetd Range

Physiological parameter	**Target range**
Heart rate	60–120 beats min−1
Systolic arterial pressure	>100 mm Hg
Mean arterial pressure	>70 mm Hg but <95 mm Hg
Central venous pressure	6–10 mm Hg
Pulmonary artery occlusion pressure	10–15 mm Hg
Stroke volume variation	<10%
FTc (flow time corrected) on oesophageal Doppler	330–360 ms
Cardiac index	>2.1 litre min−1 m−2
Mixed venous saturation	>60%
Tidal volume	6–8 ml kg−1
PEEP	>5 cm H_2O
Peak inspiratory pressure	<25 cm H_2O
pH	7.35–7.45

C. Secure Communication

Considering regulatory requirements for handling medial data, special care must be given to the data which is in motion and rest. Public Key Infrastructure (PKI) based encryption and decryption, can be effectively applied across the communication end points. Since there are no storage requirements, the data at rest is not critical for this system.

IV. SYSTEM SIMULATION

The efficacy of the system is calculated by simulating the physiological parameters using medical device simulators. The FHIR interfaces provided by the simulators are used for communication of the physiological parameters to the cloud platform. The FHIR interface built using HAPI FHIR framework turned out to be an excellent choice for the implementation of the system. The “observation” resource type of FHIR protocol is utilized

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for the communication of the physiological parameters. The protocol is light weight and consume very less data bandwidth.

Cloud service providers gives good infrastructure to onboard the hospital entity and secure communication channel. Considering real time communication requirements of the medical data, Advanced Message Queuing Protocol (AMQP) communication channel is the preferred mode communication between hospital connector and cloud module.

V. CONCLUSION

Considering the importance of procuring healthy organs for organ transplantation, the described system is best suited to be run by organ procurement agencies or providers. This system can be run as a common system for a region or a country and every providers/hospital can enroll to take the service. While care givers give more focus to the patient who has some chance to survival, this automatic system constantly monitor the physiological components of the brain-dead patient and gives important suggestion to the care givers. Care givers can act on the suggestions/alert made by the system and makes required correction to the brain-dead patient so that their monitored physiological parameters always kept under targeted range.

In future it may be also possible to automate the complete process of giving the medication for physiological parameter correction, based on the suggestion made by the described system.

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