

A Survey on Blood Leakage Monitoring in Hemodialysis Therapy

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Abstract— This paper discusses the blood leakage problem associated with hemodialysis and solution for the same. Various papers related to hemodialysis and blood leakage are analyzed for this survey.

Keywords— Hemodialysis (HD), Blood leakage, Venous Needle Dislodgement (VND)

I. INTRODUCTION

In recent years in the developed and developing countries kidney renal failure is found to be a major disease. The various treatment methods adopted for kidney failure are Hemodialysis, Peritoneal dialysis and Kidney Transplant [1]. Out of the above mentioned three methods Hemodialysis is the best treatment adopted by most countries for kidney renal failure.

Hemodialysis working[7]

- A Hemodialysis machine has a dialyzer filter which cleans the blood.
- The doctor makes an access into our blood vessels. This is done with minor surgery, usually to our arm. Then blood is taken into the dialyzer.
- The dialyzer has two parts one part for our blood and the other part for a washing fluid called dialysate. A thin membrane separates these two sides.
- Smaller waste products such as urea, creatinine and extra fluid pass through the membrane and are removed. Blood cells, protein and other important things remain in our blood because they are too big to pass through the membrane.

II. RELATED WORKS

A. Current Status of Dialysis Therapy in Korea

In[1], it is described that, in recent years in Korea kidney renal failure is found to be a major disease. The various treatment methods adopted for kidney failure are Hemodialysis, Peritoneal dialysis and Kidney Transplant. Out of the above mentioned three methods Hemodialysis is the best treatment adopted by most countries for Kidney Renal failure. In order to improve the Hemodialysis performance, Korean Society of Nephrology(KSN) started Patient Data

collection through online. The outcome is that the HD performance has been improved. In this method the hemodialysis performance is improved and shall be able to provide guidelines for hemodialysis. The main problem is that it does not give any specific blood leakage method and also guidelines are not practically verified.

Advantages

- Accuracy of HD increased
- Provides a guideline for HD
- High accuracy to detect the symptoms

Limitations

- Does not detect blood leakage
- Does not provide the practical verification
- Guidelines are based on assumptions

B. Venous Needle Dislodgement In Patients on hemodialysis

It is described that, even though Hemodialysis is the best method for Kidney Renal failure the various technical problems associated with Hemodialysis are Venous Needle Dislodgement(VND) [2], blood clotting, power failure, air in blood lines, dialyzer reaction. Out of the above listed technical problems in Hemodialysis, VND has been reported to be a potentially serious complication and as a result of VND there will be blood leakage during Hemodialysis process. Thus blood leakage due to VND in hemodialysis is the most complicated problem and should be avoided during the Hemodialysis process. It describes the problems associated with VND, the prevention methods, provides a practice recommendations to prevent it, and reduces the risk during HD.

Advantages

- Provides a practice recommendations to prevent VND
- Reduces the risk during HD
- Describes the problems associated with VND
- Describes the prevention methods for VND

Limitations

- Does not detect blood leakage
- It can take only minutes for the patient to lose over 40% if VND occurs

C. The Development of a Blood Leakage Monitoring System for the Applications in Hemodialysis Therapy

In [3], it is described that the VND is a most important and complicated problem associated with HD so a continuous monitoring of blood leakage has to be done during hemodialysis. When any blood leakage monitoring device is used, an alert component (such as sound and or a warning light) or a wireless module that shall be present in the

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monitoring device can give a warning indication to the health care worker about the blood leakage and they can take the necessary action immediately to prevent the blood leakage. This product detects the blood leakage during HD. When comparing with [3] it is more efficient because it detects blood leakage with 0.01 ml, it can monitor continuous 41 hr and can give continuous alert for 18 hr.

Advantages

- Detect the blood leakage during HD
- It detects blood leakage with 0.01 ml
- It can monitor continuous 41 hr
- It can give continuous alert for 18hr

Limitations

- It operates in small distance
- It requires high operating power
- The wireless transmission is insecure
- It requires 1.6 sec to detect blood leakage

D.Redsense blood loss detection device for venous needle dislodgement monitoring in hemodialysis

It is described that the Redsense is a device for detecting the blood loss during the hemodialysis due to VND[4]. The device has warning indication through an audible alarm unit and using a red LED and a sensor patch. When the blood leakage occurs the sensor patch absorbs it. The alarm unit transmits infrared light through an optical fiber to the sensor, which is placed over the venous needle access site. Blood leakage at the access site interrupts the infrared signal, activating a red warning light and audible alarm. The alarm unit is reusable from patient to patient as it does not make any internal contact with patient blood, it has an internal memory to store the patient date in every second for a 20 treatment.

Advantages

- Detect the blood loss during HD
- The alarm unit can be reused

Limitations

- Requires high operating power
- It does not have wireless transmission

E. Highly Sensitive Optical Sensor System for Blood Leakage Detection

In [5], it gives a description of how the sensitivity of the blood leakage detection can be improved using laser light with 680 nm. The basic principle of this approach is light attenuation by blood cells. When the light travels through non transparent medium light wave undergoes scattering and attenuation. It determines that the concentration of blood as both are linearly related by measuring the attenuation of the light. The leak blood concentration is one of the most important quantity that is measured using this method and this quantity is not given any other method. In all other method the leakage detection is based on some threshold level. If the leak blood concentration exceeds this threshold then blood leak is detected.

Advantages

- Improve the sensitivity of blood detector sensor

- Uses beam splitter and side mirrors
- Multi reflection method is used to enhance the sensitivity
- Provides linear sensitivity with blood concentration

Limitations

- Narrow beamed laser is required
- It does not have wireless transmission

F. Robust spectral leak detection of complex pipelines using filter diagonalization method

It is explained that the control and managing of pipelines have been assuming a major importance for all kinds of fluids[6]. When the fluid is like oil or harmful liquid for the necessity of human beings, the monitoring of pipeline becomes extremely fundamental. Spectral analysis response is important based on the reflection according to fast detecting systems. Among spectral analysis response techniques, Fast Fourier transform (FFT) is rated. Different other techniques are utilized, but when comparing to FFT they are costly and difficult to be used. An interesting technique, used in nuclear magnetic resonance data processing is Filter Diagonalization Method (FDM) for tackling FFT limitations. It can be used by considering the pipeline, especially complex configurations, as a vascular apparatus with arteries, veins, capillaries, etc. The thrombosis for human vascular apparatus, that might be occur, can be considered as a leakage for the complex pipeline. The research proposes the use of FDM according to two algorithms. The first algorithm is a direct transformation of FDM application, while the second includes robustness and a regularization technique to solve problems that may emerge in processing data.

Advantages

- Detects leakage in HD pipes
- Uses an efficient Spectral analysis technique

Limitations

- FFT analysis has more number of limitations.
- Detects only the leakages in the HD pipes
- Does not detect the leakage due to VND.

Table 1 : Various Survey Papers Comparison

No	Title	Basic Concepts	Advantages	Disadvantages	Other Features
1	Current Status of Dialysis Therapy in Korea[1]	Patient data collection through online to improve hemodialysis	Accuracy of HD increased Provides a guideline for HD High accuracy to detect the symptoms	Does not detect blood leakage Does not provide the practical verification Guidelines are based on assumptions	Can be used to create different procedure for different patients
2	Venous Needle Dislodgement In Patients on hemodialysis[2]	Venous Needle Dislodgement	Describe the problems associated with VND Describes the prevention methods for VND Provides a practice recommendations to prevent VND Reduces the risk during HD	Does not detect blood leakage It can take only minutes for the patient to lose over 40% if VND occurs	Typical blood flow rates of 400 to 500 ml/minute High frequency of occurrence on venous needle dislodgement
3	The Development of a Blood Leakage Monitoring	Blood Leakage Detection	Detect the blood leakage during HD It detects blood leakage with 0.01 ml	It operates in small distance It requires high operating power The wireless transmission is	Bracelet Monitoring Device Uses photointerrupter (TCST 110).

	System for the Applications in hemodialysis Therapy[3]		It can monitor continuous 41 hr It can give continuous alert for 18hr	insecure It requires 1.6 sec to detect blood leakage	Bluetooth wireless module(CC2540), power and alert components (piezoelectric buzzer, SMD LED)
4	Redsense blood loss detection device for venous needle dislodgement monitoring in hemodialysis[4]	Blood loss detection device for VND	Detect the blood loss during HD The alarm unit can be re used	Requires high operating power It does not have wireless transmission	Sensing sensitivity approximately 1 ml The blood leakage detection by electrical conductance
5	Highly Sensitive Optical Sensor System for Blood Leakage Detection[5]	Attenuation of laser light by blood cells	Improve the sensitivity of blood detector sensor Uses beam splitter and side mirrors Multi reflection method is used to enhance the sensitivity Provides linear sensitivity with blood concentration	Narrow beamed laser is required It does not have wireless transmission	Side mirrors are used to enhance the sensitivity Maximum sensitivity at 4×10^{-6} volume of blood concentration Laser wavelength used is 680nm
6	Robust Spectral Leak Detection of Complex Pipelines using Filter Diagonalization Method [6]	Leakage Detection of complex pipelines	Detects leakage in HD pipes	FFT analysis has more number of limitations. Detects only the leakages in the HD pipes Does not detect the leakage due to VND.	Uses two algorithms: Direct transformation of FDM application, robustness and a regularization technique to solve ill-posed problems that may emerge in processing data

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III. CONCLUSION

In this paper we compared various concepts related to kidney failure and Hemodialysis and blood leakage in Hemodialysis and found that Hemodialysis is the best solution for Kidney Renal failure. The most challenging problem in Hemodialysis is blood leakage and leakage should be monitored and must be controlled during the Hemodialysis procedure.

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