Integrated Vital Sign Monitoring of Haemodialysis Patients: Pilot Study

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Abstract
Hypotensive episodes continue to be a major problem for many patients receiving haemodialysis and nursing intervention is often required. 39 patients were recruited to assess whether integrated vital sign monitoring can help nurses predict or even prevent the occurrence of hypotensive episodes. Continuous monitoring of ECG, SpO2 and peripheral temperatures were recorded. Blood pressure, pulse, tympanic temperature and critline were recorded every 15 minutes. Patients showed consistent trends during each of their sessions and differences are being identified between those stable and less stable on dialysis. Variations in the pattern and fusion of vitals signs could identify those who were able or unable to compensate in a hypotensive episode. Tympanic temperatures of patients were between 35.5-36.5°C and peripheral temperatures were lower than the tympanic. Frequent monitoring is effective in detecting patient blood pressure trends during dialysis. It is suggested that repeated vital sign monitoring of less stable patients should be implemented to detect possible deterioration.

Key Words: Data Fusion, Haemodialysis, Hypotension, Temperature, Vital signs

Introduction
Although technology in haemodialysis is continually advancing, nurses still have to cope with the increasing challenge of dialysing an ageing population, who often have associated co-morbidity (Davenport, 2006). Hypotension, nausea and cramp are common events experienced by dialysis patients (Maggiore et al. 2000; Dheenan and Henrich, 2001), particularly by the elderly. Past studies have assessed sophisticated integrated vital sign monitoring such as Data Fusion algorithms in critical care and found that it is capable of detecting patient deterioration (Tarassenko et al. 2006). Data Fusion uses computational tools to look at real time changes in vital signs in their totality rather than individually. The present study was organised by Professor Christopher Pugh and Professor Lionel Tarassenko of the University of Oxford. The
aim of this study was to assess whether integrated vital sign monitoring can help nurses predict and prevent hypotensive episodes on dialysis.

Current methods in preventing hypotension

Intradiastolic hypotension (IDH) occurs frequently during dialysis treatment and sometimes post dialysis. It occurs due to an insufficient cardiovascular response to the adverse effects of a relative reduction in blood volume (Palmer and Henrich, 2008) and McIntyre (2009) argues that myocardial ischaemia caused by frequent haemodialysis is associated with haemodynamic instability. Episodes of intradiastolic hypotension occur between 20-30% of treatments (Donauer et al. 2003, Palmer and Henrich, 2008).

Not only do patients become ill and distressed at the time but there may be long term cardiac and cerebral effects (Davenport, 2006). In addition the management of hypotensive episodes often results in ultrafiltration rates being reduced and/or extra fluid being given so the patients who thus do not reach their target weight and suffer the consequences of fluid overload. Moreover, patients experiencing hypotension are also in need of direct nursing intervention, therefore adding to the nursing daily workload (Déziel et al. 2007). There have been several progressive studies in the prevention of hypotension and management; however, temperature cooling and sodium profiling appear to be the preference in clinical studies (Palmer and Henrich, 2008).

While these and other methods are used with the intention to prevent and manage intradiastolic hypotension there appear to be few studies on monitoring systems which detect the physiological changes before deterioration in the patient’s condition occurs. Integrated vital sign monitoring (or Data Fusion) has been used successfully in other areas of healthcare and this study explores its use in dialysis.

Integrated monitoring

Integrated vital sign monitoring has been tried in other areas of medicine. The use of a sophisticated integrated monitoring system using a data fusion algorithm called Biosign was applied on 150 patients over a 24 hour period and then again 5 days later in a general ward. The study was done over a 2 year period and patients with cardiac
failure and respiratory problems were recruited. By reviewing patient trends, 652 of the 690 Biosign alerts were deemed to be true episodes of physiological changes and abnormality. Therefore, with the use of such sophisticated technology, the real-time physiological changes can alert the medical team before an adverse event occurs (Tarassenko et al. 2006).

Furthermore, Mancini et al. (2007) looked at an automated system using a fuzzy logic control which would change the ultrafiltration volume according to the continuous variations in blood pressure to potentially reduce the occurrence of hypotension in their patients. However, with such a programme there is a possibility that the target dry weight may not actually be reached (Mancini, et al. 2007). With the continuous monitoring of vital sign parameters, Data Fusion could detect the changes in cardiovascular response and alert nursing staff so they prevent hypotensive episodes from occurring.

Current methods in predicting IDH
The monitoring of haematocrit levels; the level of red blood cells in the blood volume has been used to predict hypotension. It has been suggested that modifying the ultrafiltration rates to keep the hematocrit level 2 units below the patients established threshold can reduce hypotensive symptoms and episodes. However, patient thresholds would need to be established (Steuer et al. 1996). Furthermore, relative blood volume (RBV) has also been used to predict hypotension. Steuer et al. (1994) hypothesised that the haematocrit levels increase as blood volume decreases as well as the mean arterial pressure and that the sudden changes in the blood volume are predictors of an intradialytic event. However, an observational study by Andulli et al. (2002) found that a reduction in RBV during a treatment did not have the ability to predict the onset of a hypotensive episode.

Materials and Methods
After obtaining Ethics Committee approval, patients dialysing 3 times a week on regular haemodialysis who were known to be stable or unstable were asked if they would like to take part. Overall 40 patients were recruited and consented; 20 control (stable), and 20 unstable. However, due to death, patient satellite transfer to other
units, or transplantation, 30 patients completed the study. Patients on haemodiafiltration (HDF) or biweekly session and anyone under 18 were excluded. 4 consecutive sessions were monitored followed by a further 4 session 3 months later. Blood pressure, pulse, tympanic temperature and critline readings were recorded by the research nurses. Any patient symptoms, nursing interventions and activities were electronically documented. In addition, continuous monitoring of peripheral temperatures of the wrist and mid bicep region of the non-fistula arm and electrocardiogram (ECG) and pulse oximeter oxygen saturation (Sp02) were used, but the nurses were blinded to this. The temperature of dialysis machines were programmed to 37 degrees Celsius (°C) unless stated differently in patients prescriptions. In addition, patients were asked to fill out a questionnaire after each treatment asking them how they felt since their last treatment and how they felt during their current session. Symptoms experienced in between treatments were also documented thus allowing us to make comparisons between the 1 day gap and 2 day gap of their weekly treatment schedule.

**Results**

*Blood pressure stability*

The research nurses were not blind to pulse and blood pressure monitoring as they were continuously displayed on the dialysis machine. There were some differences in stable and unstable patients in recovering from a hypotensive episode. Those who were deemed ‘stable’ were able to respond and compensate in a hypotensive event. In this case the nurses did little intervening; the patient only needed to be put in minimum ultrafiltration for 5-10 minutes and then resume treatment. Some patients who had frequent hypotensive episodes needed further intervention, such as needing to be put in the Trendelenburg position, requiring a bolus of normal saline and temporary cessation of fluid removal. The data fusion algorithm indicates that there is a reduction of Sp02 and an inability in cardiac compensation to return the blood pressure to a normal state. Furthermore, the peripheral temperatures increased at the time of these hypotensive episodes. It was observed that there were a minority of patients who were generally hypotensive, but were asymptomatic and were alert and orientated. As a result, no nursing intervention was initiated.
Temperature variations
The patients’ peripheral and tympanic temperatures were below 37°C and it rarely reached 37°C. Peripheral temperatures were 1 or 2 degrees lower than the recorded tympanic temperature. There was a slight increase in tympanic temperature during the course of the treatment in those whose dialysate temperature was generally programmed at 37°C.

Questionnaires
The results for the questionnaires indicate that some patients felt better after their first treatment after the 2 day gap while others felt better after their second treatment of their weekly regimen. However, these results are inconclusive.

Discussion
Throughout the study, patient blood pressure trends and pulse readings were observed. For some, the normality of a low blood pressure without any life threatening symptoms was typical. While for others, the experience of hypotension was intolerable and nursing intervention was required. It is thought that the use of vital sign monitoring can identify those who are unstable on dialysis and would benefit from frequent monitoring to prevent such common hypotensive episodes. Studies such as Mancini et al. (2007) are promising in adding to potential technical advancements in preventing hypotension by using blood pressure monitoring as a key parameter in automatic systems.

Individualised Care
The continuous one to one or one to two care that the research nurses provided throughout the treatment session to document patient activities and nursing interventions may have influenced the outcomes of some of the results. In general customary day to day care, the nurse moves around the room to attend other patients and as a consequence, maintaining dialysis under ‘normal’ conditions was hard to achieve. Furthermore, the individualised care those patients received for 4 consecutive sessions may have had a minor positive impact on their quality of life (Patti et al.)
2003) and better clinical outcomes (Frick, 2003). Therefore, patient satisfaction with the care received may have been increased as they were treated exclusively within clinical practice (Radwin, 2000). Moreover, there is an increase in interpersonal care the patient receives and therefore the promotion of health is enhanced. Moreover, the research nurses were not blind to the blood pressure and heart rate readings as they were visually available on the dialysis machine. As a result, the temptation to intervene and prevent a normal course of events may have occurred on several occasions due to the constant presence of the research nurses. As a direct result, the occurrence of a hypotensive episode may have been prevented and thus potential data may have been lost. This pilot study points towards the need for less direct contact between nurse and patient in order to minimise such outcomes.

*Monitoring for ill patients and new starters in renal care*

It was observed in this study that some patients had high blood pressure at the beginning of the treatment session that would gradually decrease throughout the session. Other patients may have started with a low blood pressure and as the dialysis treatment continued, the blood pressure increased. Furthermore, patient trends varied and may have had fluctuations of high and low blood pressures throughout their treatment, which to these patients is normal and results in no symptomatic problems. Therefore, the monitoring of patient vital signs is not necessary for all patients. It is suggested that vital sign monitoring could be used on patients who are new to dialysis in order to assess and build an understanding of their tolerance to fluid removal and blood pressure trends. The frequent monitoring of patients using Data Fusion, especially for new starters, could be used as a tool to provide early warnings to the nurse and also provide comfort and added safety for the patient. In addition, there are patients who are less able to tolerate dialysis than others and these patients may need frequent monitoring to minimise the risk of hypotensive episodes. Therefore, the use of such data sets and monitoring can enable nurses to recognise blood pressure trends for patients during a treatment and act accordingly.
Temperature differences

It was observed early on in this present study that the patients’ tympanic temperature was lower than normal. Most patients were between 35.5-36°C and majority of their prescriptions for dialysate temperature was programmed at 37°C. Some patients who are known to be hypotensive on dialysis had already had their dialysate temperature reduced to 36°C on their prescription before the start of the study. The current interest in temperature cooling of dialysis machines has been found to have positive effects in reducing the incidence of hypotensive episodes (Donauer et al. 2003). A study by Donauer et al. (2003) recruited and assessed the hypotensive episodes, blood pressures and blood volume regulation of 17 patients. Each person was their own control and it is suggested that hypotensive episodes were more recurrent in regular haemodialysis patients than those receiving on-line hemodialfiltration (HDF). By cooling the dialysate the authors had found that there was increased haemodynamic stability for patients on regular haemodialysis than when they had higher dialysate temperatures. In addition, the occurrence of hypotensive episodes in patients on HDF reflected the same amount as those who had a cooler dialysate temperature programmed for their treatment.

Work by Ayoub and Finlayson (2004) indicates that reducing the temperature of the dialysate is effective in reducing the occurrence of hypotension. Furthermore, the patients reported that they felt more energetic when the dialysate was programmed to 35°C. In addition, lowering the dialysate temperature to approximately 35.2°C can positively ease the cardiovascular workload during fluid removal (Maggiore et al. 2000).

Vital sign monitoring as a predictive tool

Although many methods are proposed for preventing and managing hypotension they are not always successful, what is really needed is a tool to detect hypotension before it occurs. Some patients are able to feel that they are entering a hypotensive state and are able to express this to a nurse before it progresses to a more serious state. Whilst to others it happens suddenly and a prompt nursing intervention is required due to the lack of warning signs that a hypotensive episode is about to occur.

The advancement of using on-line equipment as clinical tools within the dialysis setting is vastly increasing. Bio-feedback tools and other monitoring devices need to
be tested further and in greater depth to make the case for integrated vital sign monitoring as a useful step forward in preventing hypotension. There has been research to suggest that with improved technology and new generation equipment and dialysis machines, the quality of life is improved and that there is increased cardiovascular stability (Locatelli *et al.* 2005). However, there is still the issue of cost and the addition of such tools may not be feasible (Locatelli *et al.* 2005). However, it has been suggested that patients who have heart instability such as poor left ventricular function or ischaemic heart disease are more at risk of hypotensive episodes (Rubinger *et al.* 2004). Therefore, the benefits of detecting such physical implications early can possibly reduce the risk of hypotensive episode in the long term treatment of dialysis patients (Rubinger *et al.* 2004).

*Limitations of the study*

The nurses were not blind to some of the parameters being monitored and this could have influenced decision making and thus prevented some of the hypotensive episodes that would otherwise have occurred. The aim of the study was not to prevent hypotensive episodes but to collect data that was relevant and to sift through the vital parameters to see whether continuous vital sign monitoring is capable of detecting hypotensive episodes before they may occur. However, as a pilot study, the use of vital sign monitoring for less stable patients is indicated.

*Future recommendations*

The application of monitoring systems is fast becoming more mainstream in nursing care. The incorporation of Data Fusion in the dialysis setting could become an integral part of renal nursing care. It could free the nurse to attend to other duties and alert the nurse in situations of real time patient deterioration. From a patient’s perspective, the use of additional monitoring could make vulnerable patients feel more secure and safe knowing that the care they receive is current, advanced and is supplementary to the quality nursing care they currently receive. Such advanced monitoring can be applied accordingly and can be used nationally or even globally due to the swift advancements in medical technology and safety.
Conclusion
Results indicate that frequent monitoring is effective in identifying patient blood pressure trends during their dialysis treatments and thus provide more individualised care that could potentially prevent hypotension. Furthermore, for the majority of patients that have cardiac problems, ECG monitoring seems to be an invaluable device in early detection in changes in cardiac arrhythmias. The tympanic temperatures of patients also suggests that further study into correlating patient’s temperature and dialysis machine temperature at the beginning of each session may be a small intervention that could potentially decrease the frequency of hypotensive episodes.
References:


