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A Bi-directional Interface linking a Dialysis Network with a Clinical Information Network

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Abstract
A clinical information system called OACIS is used in the Renal units of major hospitals of South Australia, integrating both patient dialysis and pathology data for clinical assessment. Fresenius haemodialysis machines have been installed in the majority of these Renal units and can be networked by the Finesse Basic system with collection of all patient treatment data into a local database (FinDB). In an effort to help care givers by minimizing data entry and reducing transcription errors, a bi-directional interface (FOXHL7) has been developed linking OACIS with FinDB.
FOXHL7 provides automatic transfer of patient treatment data from FinDB to OACIS while allowing dialysis treatment orders to be exported from OACIS to Finesse prescriptions in FinDB. Data automatically uploaded to OACIS includes the patient's pre and post treatment weights, blood pressure measurements and other dialysis treatment information. Care providers can create new dialysis orders on any OACIS computer workstation with this information being downloaded into FinDB prescriptions at the appropriate dialysis centre.
FOXHL7 is written in Microsoft Visual Basic and uses TCP Client/Server Active X technology to exchange HL7 Protocol messages with the OACIS Gateway engine. Transfer of the data occurs in real time as the dialysis treatment data becomes available in the Finesse database. The gateway processes the messages and new treatments are stored in OACIS. Changes to dialysis orders in OACIS are intercepted and broadcast to FOXHL7 for downloading to corresponding prescriptions in FinDB in real time. FOXHL7 resides on a Finesse Server running continuously seven days a week.

Keywords: Haemodialysis, OACIS, Fresenius, Finesse Basic, interface, FOXHL7

1. Introduction

Health care is an information intensive and knowledge-based sector that is undergoing fundamental shifts in the way care is delivered and managed. The need to share clinical knowledge across the health system and provide an integrated, seamless service to patients is crucial.

The experience in renal care in Australia and New Zealand shows that most dialysis units still document their treatment data either in paper based systems or isolated renal electronic systems (1). With approximately 20,000 patients in Australia needing either dialysis or transplantation (2) and the cost per patient approaching $70,000 per year (in-centre haemodialysis) renal medicine practice is a very expensive process and the need to make efficiencies in this speciality is paramount. One area that requires attention is the practice of managing patient renal information in a cost effective manner.

The installation of a clinical information system (OACIS) (3, 4) in the major hospitals of South Australia provides health care workers with a standardized clinical viewing platform. Once trained in the use of this application, care providers can move from one hospital to another and use the same clinical viewer with maxi-

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mum efficiency without further training. This system connects with the majority of departmental systems including patient administration, outpatient services, pathology, radiology, emergency and operating systems as well as a renal module and provides a dynamic view of patient data arranged in a roster list tailored for each care provider. Patient information is shared across all the hospitals and allows care providers fast access to patient data at the point of care.

A local dialysis network (Finesse Basic) (5) also has been installed in each dialysis unit (see Table 1) with the online capture of all patients' data from their haemodialysis treatment, but this information is stored locally at each dialysis unit.

Care providers in the dialysis units were required to keep both systems up to date as Finesse Basic lacked an interface to OACIS and the time spent on entering information on both systems was seen as counter-productive to patient care.

This manuscript details the development of a bi-directional interface (FOXHL7) to connect both OACIS and Finesse so treatment information in the dialysis network can be uploaded automatically to the corporate hospital system while regimen orders created in OACIS are downloaded to Finesse, synchronizing both databases with the latest relevant haemodialysis data. The regimen orders for dialysis can be entered from any OACIS clinical workstation in the hospital network and these dialysis orders (prescriptions in Finesse) will be automatically transferred to the Finesse server where the patient's data resides.

Treatments uploaded to the OACIS via the FOXHL7 interface utilize the information provided by the current Finesse prescription order; the synchronization of data from both OACIS and Finesse means that accuracy of treatment information is ensured without the requirement of care providers entering data in each system.

2. Methods

Code	Hospitals with OACIS	Dialysis Centres with Finesse
FMC	Flinders Medical Centre	In-Centre
HAR		Hartley Dialysis Centre
HDC		Hampstead Satellite Centre
LMH	Lyell McEwin Hospital	In-Centre
MDC		Modbury Dialysis Centre
MGH	Mt Gambier Hospital	
MOD	Modbury Hospital	
NHS	Noarlunga Hospital	In-Centre
PAG	Port Augusta Hospital	Regional Satellite Centre
QEH	Queen Elizabeth Hospital	In-Centre
RAH	Royal Adelaide Hospital	In-Centre
RGH	Repatriation General Hospital	
WAY		Wayville Satellite Centre
WCH	Women's and Children's Hospital	

Table 1: OACIS and Finesse distribution in the hospital network of South Australia.

2.1. OACIS

OACIS (Open Architecture Clinical Information System, Emergis Canada) (4) is a clinical information system with patient lists in user and system rosters comprising of current displays of renal therapies, pathology, radiology, patient encounters, pharmacy and orders management.

The OACIS Server is connected to the major hospitals in South Australia and interfaces with the existing Hospital systems such as the Patient Master Index (PMI), Admissions Discharges and Transfers (ADT), and Pathology systems (LABS) to provide a shared global database warehouse of patient medical information (see Table 1 and Figure 1).

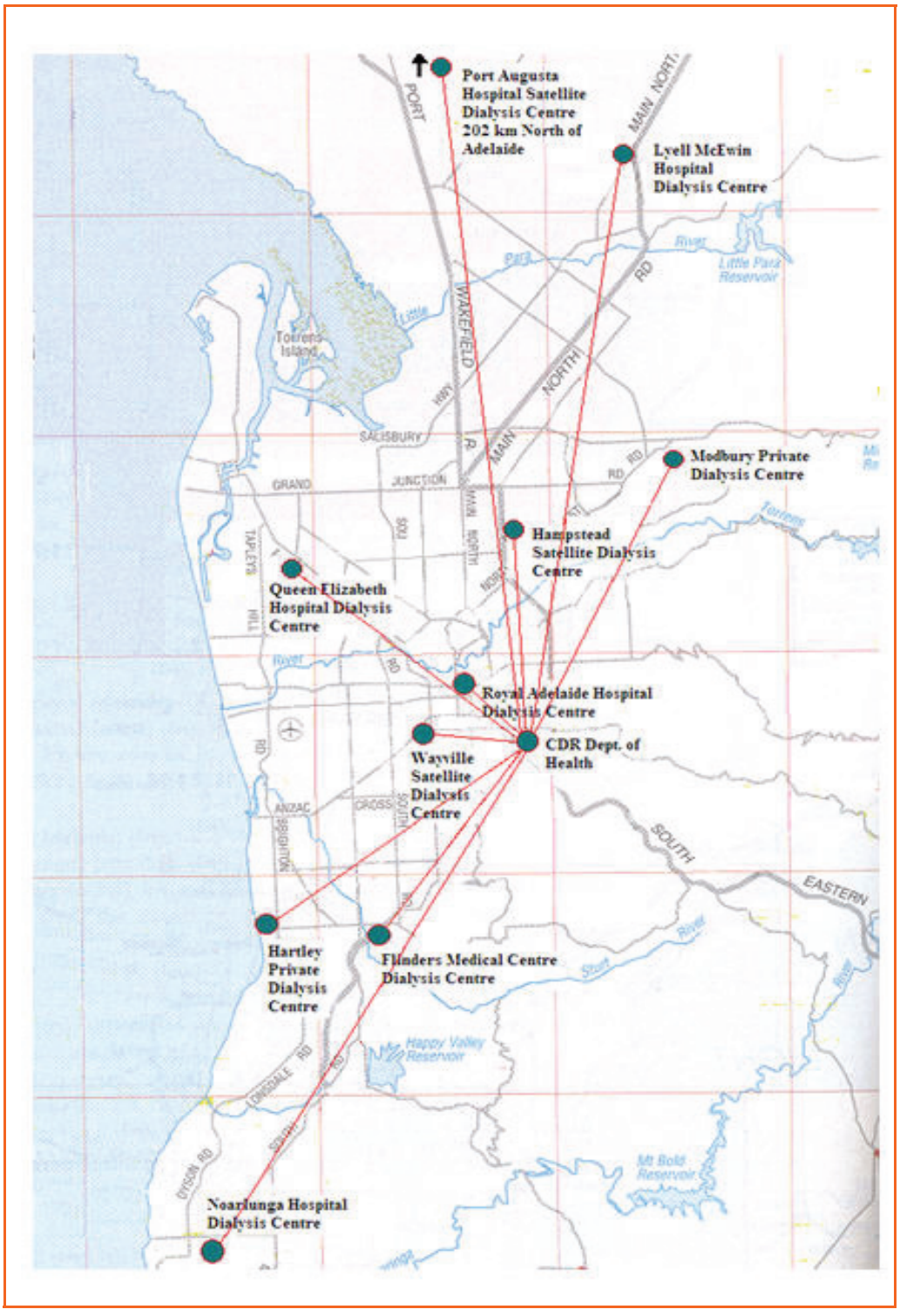


Figure 1: Locations of dialysis centres with FOXHL7 Interface links to OACIS in the hospital network.

The OACIS Clinical Viewer Application is operated within each Renal Unit and allows for capture of renal observations such as haemodialysis treatments. This information is stored in the OACIS Clinical Data Repository (CDR) and is available to staff on an OACIS PC Desktop in any of the major public hospitals. Furthermore the associated regional satellite dialysis units and private dialysis centres (see Table 1 and Figure 1) are connected to OACIS and can capture and review patient data in similar manner. Thus the value of OACIS in this setting is the ability of a clinician anywhere in the network to review patient information captured at any

one site in the hospital network. Further rollout of OACIS will expand the clinical network to a more complete state-wide clinical system for South Australia linking many of the regional hospitals which currently lack such support. OACIS is planned to link clinics, hospitals and specialist health units and also provide the foundation for sharing medical records with general practitioners in South Australia and interstate healthcare providers. Currently OACIS has client-server architecture but further releases will be using a Web-based deployment of the Java version of OACIS (6).

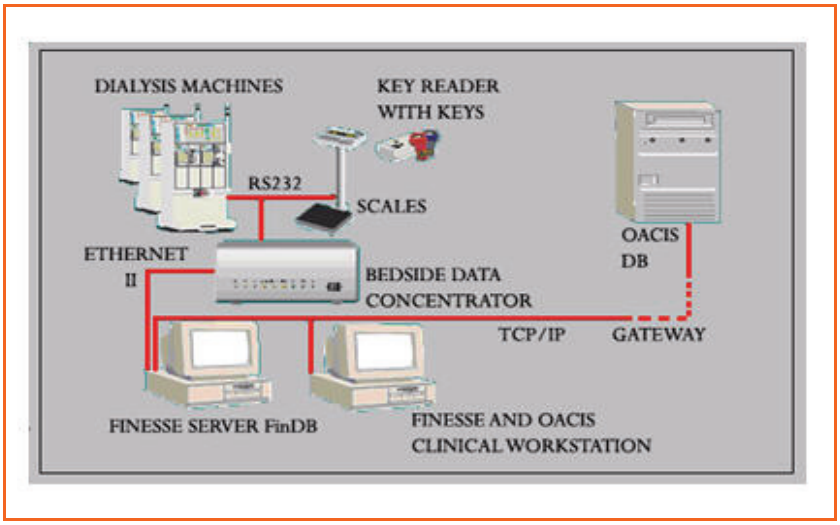


Figure 2: Finesse setup in a typical dialysis centre in South Australia.

2.2. Finesse System

Fresenius dialysis machines are used almost exclusively in the majority of dialysis units in South Australia. Finesse Basic Systems provides the computer system for these dialysis machines (Fresenius Integrated Network systems, iSYMED Germany) (5). This installation creates a local dialysis information network and features online haemodialysis treatment and dialysis regimen order information for renal patients (prescription in Finesse).

Finesse automatically captures dialysis treatment and machine parameter information from each Fresenius dialysis machine during a patient's treatment with capture of the patient weight prior to and after the treatment using electronic scales. EEPROM key readers or Smartcards are used to verify the patient's identity for each treatment depending on the Fresenius dialysis machine being used. A patient key is inserted into the key reader and a number identifying the patient is stored on the key using EEPROM memory. This patient data are transferred via RS232 communication to a Bedside Data Concentrator (BDC) which communicates over the network using Ethernet II network protocol (later generation BDC communicates with TCP/IP instead) to a Finesse Server via an installed file management service (see Figure 2). Clinicians can monitor the dialysis information being acquired in Finesse and import the finished treatments into a Finesse database (FinDB). The OACIS Clinical viewer runs on the same PC workstation, thus both dialysis and pathology information are available to a care provider at this desktop PC. The FOXHL7 Interface is the integration engine which makes the dialysis information available to all metropolitan and country hospitals which use the OACIS Clinical Viewer (See Table 1 and Figure 1).

2.3. FOXHL7 Interface

2.3.1. Pre-Integration

The use of OACIS required manual entry of patient dialysis treatment observations which necessitated at least one hour a day of a clinician's time to complete this task for all patient treatments in a typical dialysis unit. Finesse provides automatic dialysis machine capture of relevant renal data but was not designed to link to OACIS. If an interface could be developed to transfer the collected haemodialysis data from Finesse to OACIS while downloading the saved OACIS dialysis regimens to Finesse prescriptions, then staff could be relieved of the onerous duty of manual data entry at the end of each day, freeing up their time and allowing better care management of their patients.

2.3.2. Post-Integration

FOXHL7 - Finesse-OACIS Bi-directional HL7 standard message protocol interface was developed to provide the link between both systems. The interface consists of two application modules running in their own 32 bit application space controlled by the windows operating system. Should one application fail then the other continues unaffected. The interface is written in Microsoft Visual Basic 6 and each module opens an Access database with attached links to the local FinDB database where the treatment and prescription data are

archived. The Interface uses the Active X Winsock control to communicate with the OACIS Gateway Engine using TCP/IP protocol and the HL7 Australian Health Standard messaging format (7) is used in communication with the Gateway. The interface operates continuously each day except for intermittent housekeeping operations such as performing a database compact operation to clean the database and reduce its size. The FOXHL7 interface applications are installed on the Finesse Server computer and connect both to FinDB via attached links and also to the OACIS Database via the Gateway engine over the health network.

Figure 3 illustrates the data transferred by the FOXHL7 interface system. Dialysis treatment data uploaded to OACIS include dialysis start and end times, pre and post weight and blood pressure measurements, dialysis machine information, averaged running sheet treatment data as well as the dialysate constituent concentration values.

Dialysis regimen information downloaded to Finesse include the scheduled type and time of dialysis, ideal weight, blood flow rate and dialysate flow rate, ultrafiltration rate and sodium profile information, vascular access information, anti-coagulation settings and the dialysate constituent concentration data.

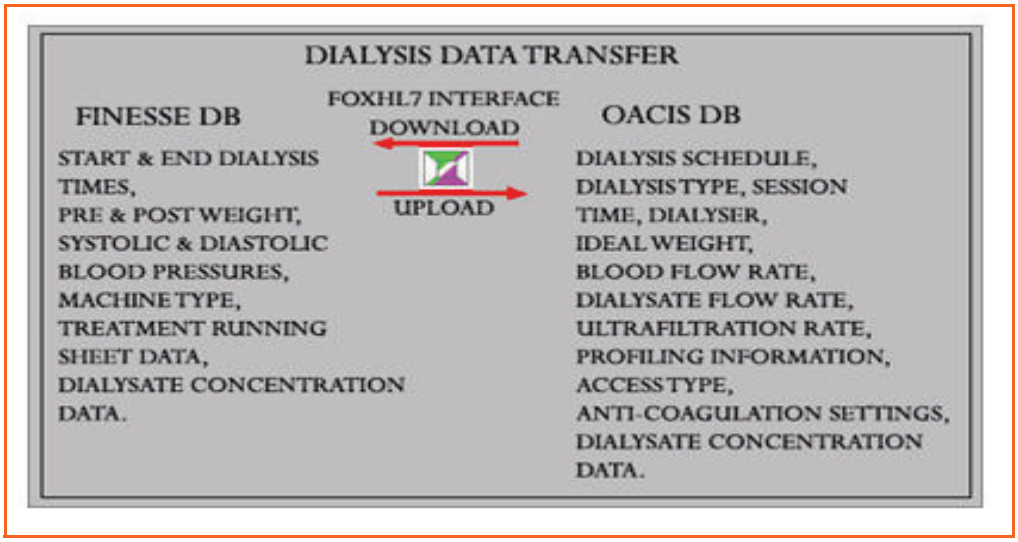


Figure 3: Description of treatment and regimen order data transferred between Finesse and OACIS.

3. Results

The process used by the FOXHL7 treatment interface is described as follows.After successful login using a dialog form to allow username and pass-word verification, the parent controlling form is opened (see Figure 4). The task of this form is to manage the operation of the messaging form, automatically opening and closing the form when required.

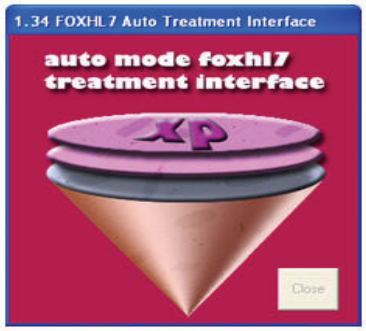


Figure 4: FOXHL7 Auto Treatment Parent Form which manages the child messaging treatment form.

Once the FOXHL7 treatment interface form is opened (see Figure 5), it queries FinDB for newly saved treatment records. If records are found then each patient treatment is displayed as a row in a Waiting Treatment data control and then sent as a HL7 communication to OACIS. Successful completion of the transfer results in a completed record of transfer being displayed in the Sent Treatment data control (see Figure 5). The sent message results in the creation of a new haemodialysis treatment record for that patient in OACIS.

This data can be reviewed by a renal clinician and edited if necessary from within the OACIS clinical viewer. Each night the interface is closed to allow Finesse systems to archive the current day's treatment data and then to re-compact the treatment database prior to being re-opened at 2am in the morning.

Care providers are required to archive the Finesse treatments into FinDB before they can be identified by a FOXHL7 query (see Figure 5) as new treatment records and the data sent to OACIS.

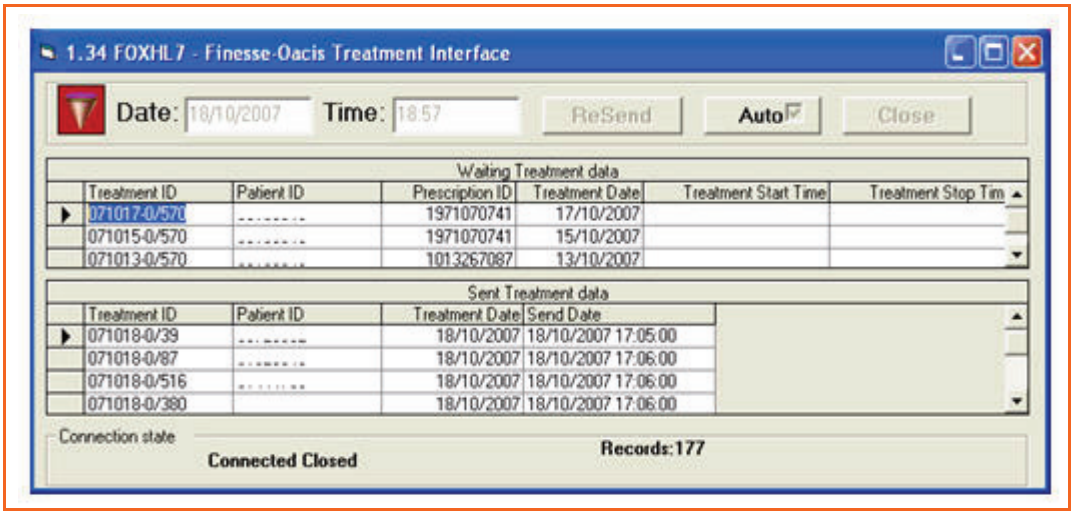


Figure 5: Treatment messaging form with waiting treatments and treatments sent successfully to OACIS.

The Summary maintenance haemodialysis form (see Figure 6) demonstrates that the information has been transferred to OACIS from FinDB (Last Changed by: Finesse 7.04 text box entry) and contains the start and end times of dialysis treatment plus captured pre and post weight and blood pressure data.

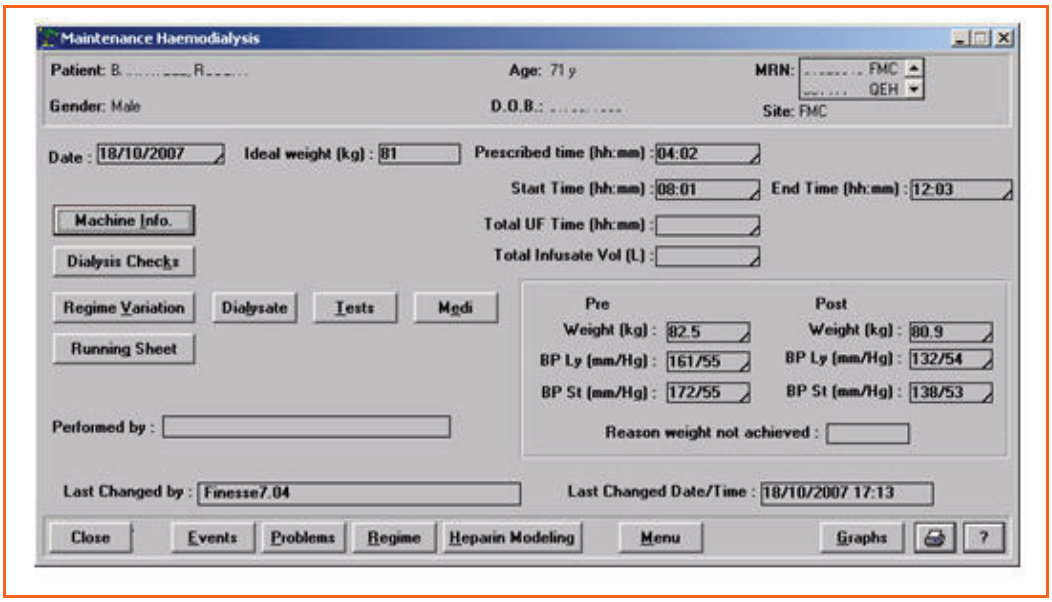
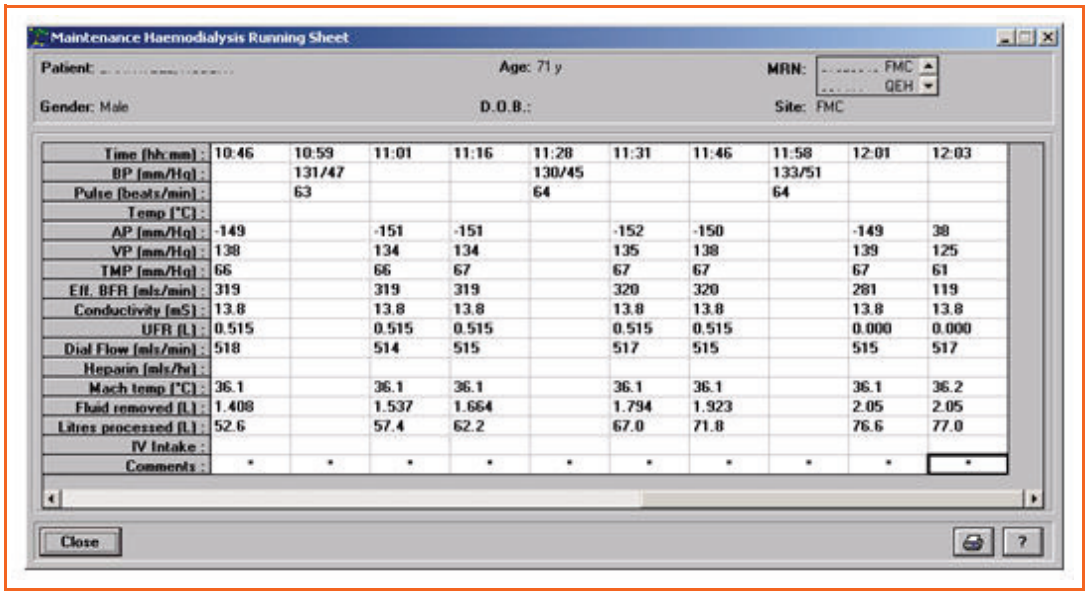


Figure 6: OACIS Haemodialysis Summary form with data from FOXHL7.

Data are populated into the Machine Info and Dialysate concentration forms as well as the Running Sheet form which can be selected by clicking on the appropriate command button. Figure 7 demonstrates the Running sheet form with data from Finesse systems automatically populating the relevant fields and provides a patient's medical and dialysis machine information during the treatment period.



Time [hh:mm] :	10:46	10:59	11:01	11:16	11:28	11:31	11:46	11:58	12:01	12:03
BP [mm/Hg] :		131/47			130/45			133/51		
Pulse [beats/min] :		63			64			64		
Temp [°C] :										
AP [mm/Hg] :	-149		-151	-151		-152	-150		-149	38
VP [mm/Hg] :	138		134	134		135	138		139	125
TMP [mm/Hg] :	66		66	67		67	67		67	61
Eff. BFR [mls/min] :	319		319	319		320	320		281	119
Conductivity [mS] :	13.8		13.8	13.8		13.8	13.8		13.8	13.8
UFR [L] :	0.515		0.515	0.515		0.515	0.515		0.000	0.000
Dial Flow [mls/min] :	518		514	515		517	515		515	517
Heparin [mls/hr] :										
Mach temp [°C] :	36.1		36.1	36.1		36.1	36.1		36.1	36.2
Fluid removed [L] :	1.408		1.537	1.664		1.794	1.923		2.05	2.05
Litres processed [L] :	52.6		57.4	62.2		67.0	71.8		76.6	77.0
IV Intake :										
Comments :	*	*	*	*	*	*	*	*	*	*

Figure 7: OACIS Haemodialysis Treatment running sheet with data from FOXHL7.

A similar process is used to perform the Prescription transfer. Figure 8 illustrates the opened FOXHL7 prescription interface. The OACIS regimen HL7 message is shown in the text box at the top and is received from the OACIS Gateway engine as a forwarded message following the creation of a Haemodialysis regimen order from an OACIS Workstation anywhere in the Hospital network. The message is disassembled into the component field values and registered as a waiting prescription record in the top data control.

On a timer event the prescription is processed and written to the Prescription table in FinDB only if the patient medical record number and hospital base site code matches that in the FinDB patient administration table which lists the current set of patients for this dialysis centre. Any new dialysis component such as an extra dialyzer type will be automatically created in the appropriate Finesse table with its individual code and corresponding description name prior to final completion of the prescription record. Once the record is successfully downloaded an entry is written in a Prescription sent table as seen in the second data control.

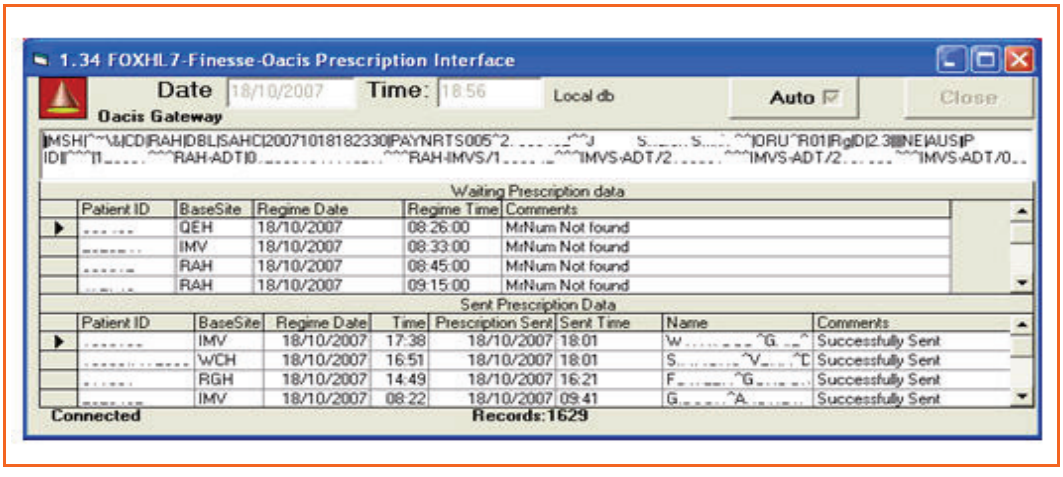


Figure 8: FOXHL7 Prescription messaging form with data received from OACIS gateway.

Figure 9 illustrates a portion of the Prescription created by the FOXHL7 interface within the Finesse system. In this view you can see data entered includes the dialysis type and dialysis time, dialyser type, access needle size, dialysate constituent concentrations, profiling information and target weight. Extra Finesse data not found in the OACIS regimen are uploaded automatically from the previous Finesse prescription (not highlighted in gray). This allows care givers to continue to use Finesse prescriptions in full functionality even though the corresponding OACIS dialysis regimen does not contain the expanded field set that is within FinDB.

HDF Prescription		Treatment Type:	Duration (h min):	
Monday:		Haemodialysis	4:30	
Tuesday:				
Wednesday:		Haemodialysis	4:30	
Thursday:				
Friday:		Haemodialysis	4:30	
Saturday:				
Sunday:	Target exchange 20.5L			
Device:	Fresenius 4008H	Art. Bloodsystem:	FMC A/V-Set MTS FA 104	
Dialyser:	F8 - Fresenius	Ven. Bloodsystem:	FMC A/V-Set MTS FA 104	
Art. Needle:	Needle Size - 15	Concentrate:	Na140/K2/Mg1/Ca1	
Ven. Needle:	Needle Size - 15	Bicarbonate	Bicarb32	
Single Needle:		Additive 1		
		Additive 2		
		Additive 3		
Use Single Needle:	No	Target Sodium (mmol/L):	140	
Art. Bloodflow (ml/min):	400	Bic. Adjustment (%):	35	
Ven. Bloodflow (ml/min);		Initial Sodium (mmol/L):		
Dialysate Flow (ml/min):	800	UF Profile:	0	
Dialysate Temp (°C):	36	Na Profile:	0	
Target Weight (kg):	59.0	Energy Target (kJ):		
		Temp Target (°C):		

Figure 9: Presentation of a Finesse Prescription report illustrating key data imported by the FOXHL7 interface (gray highlight).

Following the successful pilot of the FOXHL7 interface at the Flinders Medical Centre, the interface was installed progressively in ten in-centre dialysis units and regional dialysis centres in South Australia (see Figure 1). Figure 10 illustrates the average daily HL7 message volume delivered to the OACIS Gateway from each FOXHL7 interface as treatments are processed from each dialysis centre.

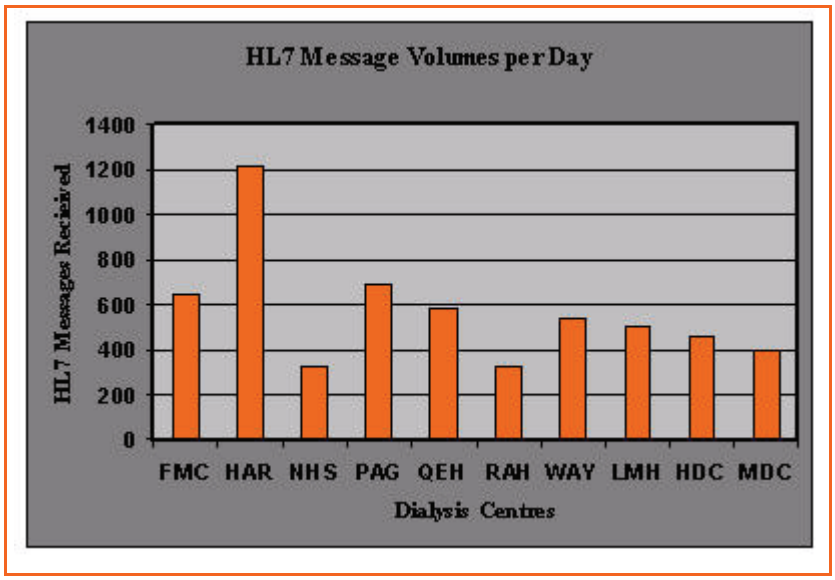


Figure 10: Daily HL7 messages delivered to the OACIS Gateway from each dialysis centre by the FOXHL7 interface.

4. Discussion

Corporate clinical systems are already part of the practice of medicine but there are disparate systems that could be but are not linked to this enterprise system. Renal dialysis database systems, blood transfusion donor database, peritoneal dialysis adequacy calculator and Australian and New Zealand dialysis and transplant registry service are examples of renal-related systems that remain outside of OACIS and require staff input. This puts pressure on care providers to attend to various systems to keep information up to date. This is most frustrating where data are duplicated in disparate systems and clinicians simply do not have the time or inclination to maintain these systems effectively.

It was considered prudent and necessary to provide an automatic exchange of information between both OACIS and Finesse so both systems reflected the current status of the patient's haemodialysis record, despite the fact that the database field content differed somewhat in both systems. The Finesse system was a dedicated proprietary database for dialysis treatment whereas the renal module of OACIS was more a generic global dialysis field set suitable to connect to many different haemodialysis machines and software products.

The development of the FOXHL7 interface significantly reduced manual entry of data in both OACIS and Finesse systems with substantial cost and clinical efficiencies. Care providers could spend their time with the patient at the dialysis machine rather than being held captive to the desktop computer at the console area of the dialysis room. Indeed one study has shown that some staff have either little experience with computers generally or either resent the intrusion of computer technology to their main task of patient care (8). With the data being automatically synchronized between both systems, perceptions of the computerised system were enhanced and confidence in the validity of patient data was high. It is recognised that high efficiency of hospital care can be achieved by the use of integration strategies, of which information systems integration is one (9). Furthermore, clinicians support the technology if it will save them time and make their work easier, especially when they already are in an environment which interrupts their patient workflow either from colleagues or synchronous technologies such as phone, pager and email services (10, 11).

Clinicians can review current dialysis data within the hospital unit or at the desk in their own office even though the patient is being dialysed in a regional dialysis centre. They can change a dialysis regimen remotely and the prescription in finesse will reflect this change, wherever the patient is being dialysed, once the FOXHL7 interface receives the message from OACIS. Data are transferred in real time rather than at the end of a dialysis shift when clinicians are free to enter data into a computerised system. Errors of transcription by staff who may be tired at the end of a shift are removed by the automatic transfer of data. Care providers can feel more satisfied in that their focus is on patient care and that the human interaction is not hindered but rather enhanced by the impact of technology on the dialysis treatment experience.

Patients usually move from one dialysis centre to another, initially at

the hospital in-centre dialysis unit as they are being educated in dialysis techniques as a new patient, then often being transferred to a regional dialysis centre much nearer to home as they become accustomed to the rigours of their treatment. However they may need to be re-admitted to a major hospital because of a vascular access problem or an acute event requiring specialized care beyond the dialysis room setting. In this continuum of care, the patient's renal treatment record is kept up to date as the relevant interface sends the information to the central OACIS Gateway while the regimen information is forwarded to each FOXHL7 interface including the appropriate site where that patient is being dialysed currently.

Thus from a programmer's point of view, FOXHL7 was designed to provide automatic flow of data where possible. It was recognised that OACIS is the major clinical information system in South Australian public hospitals and as such should be the application of choice to change dialysis orders. Therefore regimen changes are downloaded to Finesse but changes in the prescription in Finesse will not be transferred to OACIS. As OACIS is positioned as a hospital-wide system with one component being the renal module, it followed that not all treatment data in Finesse could be written to OACIS due to some restrictions in the field list in the OACIS haemodialysis tables. Similarly, the regimen order form in OACIS does not contain all the fields maintained in the Finesse prescription table.

Technological change is occurring at an ever increasing rate. More recent dialysis technologies such as blood temperature monitoring (arterial, venous and core temperature) (12, 13) and relative blood volume monitoring (% blood volume, haemoglobin, haematocrit levels) (14) could be entered into the running sheet (see Figure 7) and be available for analysis using the charting control in OACIS. It is hoped that the Java version of OACIS will allow presentations of dialysis treatment course, blood temperature monitoring and blood volume monitoring within the running sheet in the near future.

5.Conclusion

The outcome is that clinicians can supervise the patient's treatment from an OACIS desktop within a major hospital even though the patient is being dialysed at a regional dialysis centre close to the patient's home. Care providers do not have to waste their time updating both systems in order to maintain valid data for each patient and thus provide quality care for patients receiving haemodialysis treatment. The increase in patient numbers in South Australia (median age of the population approaching 40) (15) puts ever increasing demands on the health care system and greater efficiency in providing clinical information at the touch of a button is needed to cope with this trend.

In conclusion, the requirement of systems to be automatically linked allowing continuum of care across the region is important for the effectiveness of treatment delivered by the care giver with corresponding health care benefits to their patients.

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