2017 CMBEC40 Conference
Winnipeg, MB
May 23-26, 2017

ELECTRIC BED DESIGN AND FEATURES FOR NEXT GENERATION OF BEDSIDE NURSING

Gnahoua Zoabli
CISSS des Laurentides, St-Jérôme, Québec;

ABSTRACT

On Easter Sunday 2016, I was hospitalized for a week at the brief hospitalization unit of St-Eustache Hospital; An institution of which I am the chief of biomedical engineering since September 9, 2009. Beyond the great technological achievements that I benefited as a patient, I noticed a few dysfunctions from the point of view of the patient that I became. The purpose of this article is to suggest a better arrangement of medical devices at the bedside of the patient to improve his episode of care. Based on the premise that any medical device basically at the patient's bedside should be incorporated into the bed, if technologically possible, we propose the design of a first-generation intelligent medical bed, using current bedside concepts, embedded or not. Some improvements are also proposed for the accessibility of the patient to the controls of existing beds. The second generation will focus on patient communication with the nursing station. Thus, the patient call will be graded and interpreted to discriminate the regular calls to medical emergencies. The third generation will consider network communication and the incorporation of medical and pharmacological transactions from the bedside to the patient record via the bed that will be networked and the patient, geographically identifiable, in real time. One of the objectives of this article is to encourage healthcare professionals who would eventually become a client of the healthcare network to report their observations and thus contribute to alter the services from within.

Keywords: Next generation intelligent bed, Multi-level patient call, Patient-nurse communication, Electronic medical record, Integrated physiological monitoring in the bed, Clinical or medical professional as a patient.

INTRODUCTION

Across the world, the size of a health facility is defined by the number of hospital beds or stretchers in its emergency. Technological investment in either of these indicators is well justified. A later article will deal more in detail with the improvement of stretcher technology, but for now, we will consider primarily the design of a medical bed that would be appropriate in general or specialized care units. It is a sort of universal intelligent bed configurable according to the specific level of care required by the unit.

ICUs already use smart beds that incorporate certain data such as weight and height in the determination of body mass index (BMI), control of therapeutic surfaces, control of movement of the patient, sound-based therapy, pre-programmed clinical questionnaire, touch screen and multilingual display. At the bedside of each critical care bed there is a physiological monitor whose data are displayed at the central station. Each room has at least one multi-channel volumetric pump, a solute rod, wall suction and medical gases. For reasons of breaking the vector of transmission of nosocomial infections, general care beds are gradually equipped with vital signs monitors at each bedside, as well as dedicated wall suction. At the bedside of each nursing bed, the panic call button is attached to the control panel, making it easier to be accessed by the patient.

We propose a new paradigm at the bedside of the patient: unitary bedside technologies [in the bijective sense] would benefit from being incorporated into the bed in order to ensure availability and better structure the interactions. This article presents its design and feasibility with current technological means, or to be developed over time.

MATERIALS AND METHODS

The technological approach was developed according to the following criteria:

Essential technologies to incorporate to the bed to better structure patient nursing care;

Improvement of current technologies or controls for a better accessibility by the patient;

Optional technologies to consider in later generations;

Revision of the design of the bed side rail to both address the entrapment issues of elders and the safety of pediatric children;

Sketch of the proposed bed: all movements are desired motorized, as far as possible;

Economic considerations and proposal for an acceptable maximum price;

All components incorporated in the bed are considered taking into account their current market value separately. The aim is to reach a maximal recommended price that is less than half of the cumulative value of the integrated medical devices.

RESULTS

Essential technologies to incorporate to a basic bed for nursing ergonomics to patient:

a. Nurse call

   The call wire is always attached to the bed. Better incorporate it.

b. Wall Suction

   The tubing of the suction drags under or around the bed to get to the equipment that stays at the bedside of the patient. Better incorporate it.

c. Physiological monitoring (critical care) or vital signs monitoring (general care)

   For reasons of infection control or by definition, we preferably have a monitor at each bedside. Better incorporate it into the bed.

d. General patient status indicator (Red, Orange, Green)

   A light visible from a distance should indicate the general condition of the patient, depending on whether he recovers well (green), he is suffering (orange) or is in a critical condition (red). The system must be able to memorize at least the last 72 hours of the evolution of the general state of the patient.

e. Direct communication of the healthcare team with the patient [controlled by the central station]

   The nursing station shall have a unit which displays each bedside with its general status indicator in the color of the current patient status. When a call is received from a bedside, it is under the control of the nursing station that the communication is authorized and managed. Such communication would make it possible to know in advance the need of the patient and to prepare accordingly before moving at his bedside. It saves time, in efficiency, all for the benefit of the patient. At any time, the nursing station can call a patient (if he can speak) or listen to his bed to know what is happening.

Current technologies to make ergonomic for their accessibility and maneuverability by the patient

The solutions proposed are summarized in Table 1.

Table 1: Current problematics and suggested solutions

Parameters	Present situation	Problematic to solve	Suggested solution
Nurse call	Wraped on the bed frame	Difficult lateral access. Button to press tightly	On bed control PDA
Bed movement control	Manual or with lateral buttons		
One-touch [motorized] bed exit	None	New	
One-touch to Extend the bed flat [i.e. RCR mode]	ICU beds only	New for general beds	
Talk / Respond to the patient from the nurse station	Bedside communication only	new	
Patient bed control by PDA	None	new for medical beds	
Wall Succion	Wall-mount	Wrapped or crushed tubing	On head side fixed panel
Medical Air	Wall-mount	Wrapped or crushed tubing	
Physiological Monitoring [or vital signs only]	Mobile or Wall-mount	Availability	On head or foot panel

Optional technologies to consider in later generations

a. Reconciliation of pediatric [full side rail] vs adult [four half-rails]

   The beds will have to be designed to be configured in pediatric full-width boards or in four half-boards for adults.

b. Phone call to the bed via the control PDA [replaces the bedside phone].

c. Volumetric infusion pump integrated in the bed.

   The infusion is controlled, programmed and displayed via the bed display. The medication is suspended to the integrated IV pole.

d. Internet Access / Entertainment via PDA Control

   To access the entertainment at the bedside, the remote control is replaced by a PDA that controls the movements of the bed, but whose screen is wide enough to view the shows of the entertainment service provider. Such a remote control is provided as a replacement for the regular remote control at the time of signing the entertainment contract.

e. Dome of thermalization and patient insulation

   Dome of thermalization : When a patient is cautious, he remains under his blanket and so covered to the point that to give him care, he must be uncovered temporarily, the time necessary. With a dome of thermalization, like the neonatal incubators, the temperature is set to the right setpoint and there is therefore no need to use a blanket to warm the patient. This technology puts an end to hyperthermia devices in their current technological format.

   Isolation: to give care to a patient in an isolation room or simply to pay him a follow-up visit, you have to change and when you leave the room, throw away those yellow coats. It is a waste of resources in addition to being complex to implement. Some cheat at the risk of spreading the infection. We currently have one patient per room. With the insulation dome, the patient remains in his bed, which alone is pressurized positive or negative depending on the situation. Thus, no need for the staff or the visitor to change clothes; A substantial saving of resources and time. In addition, many patients can be treated in the same room, whether they require insulation or not. This technology puts an end to isolation rooms in their current technological format and increases the bed capacity of our healthcare facilities.

Proposed bed design

The design of the bed will be the subject of a separate article. For now, we have only presented the concept for its technological acceptability. See details of bed components in Table 2.

Economic considerations and proposal for a beneficial maximum price

Our intelligent bed design incorporates multiple technologies while some are rendered obsolete (bedside telephony, hyperthermia, room insulation). The suggested maximum cost of the equipment is determined as half of its cumulative value after removal of the technologies rendered obsolete. See details of bed components and cost details in Table 2.

Preliminary technological considerations for next generation of Stretchers

Without developing the stretcher as much as we did for the bed, here is our vision of the future stretcher. It includes the following parameters. See details in Table 2.

- Weight
- General patient status indicator (Red, Orange, Green)
- Touch screen, lockable
- Multilingual display
- IV pole
- Wall Suction
- Medical air intake
- Nurse call panic button
- Four-wheel braking
- USB port for charging electronic devices
- Battery shelf indicator on the control panel
- Geographical location of the current position
- Hospital Map and Stretcher Circuit
- Closest available storage space.

Table 2: Bed Parameters and Cost by Clinical and Medical Specialty

CLINICAL CONFIGURATION OF THE PHYSIOLOGICAL MONITORING INTELLIGENT BED [PRE-CONFIGURED PERSONALITIES]	Current estimated value (Can $)	HOSPITAL BED										STRETCHER
		Genral medicine	Long term care	Short hospitalization unit	Cardiology	Surgery	Recovery Room	Intensive Care Unit	Emergency Room	Birth Unit	Pediatrics	
Weight	1 000 $	1	1	1	1	1	1	1	1	1	1	1
Height	1 000 $			1			1	1	1	1	1	
Body mass index (BMI)	1 000 $	1	1	1	1	1	1	1	1	1	1	
Patient ID [including photo of the health insurance card]	1 000 $	1	1	1	1	1	1	1	1	1	1	
General patient status indicator (Red, Orange, Green)	1 000 $	1	1	1	1	1	1	1	1	1	1	1
Connection to the electronic medical record [patient index]	5 000 $	1	1	1	1	1	1	1	1	1	1	
Control of therapeutic surfaces	3 000 $		1					1				
Patient movement monitoring	2 000 $	1		1			1	1				
Sound-based therapy	1 000 $		1		1			1				
Pre-programmed clinical questionnaire	2 000 $			1				1				
Touch screen, lockable	2 000 $	1	1	1	1	1	1	1	1	1	1	1
Multilingual display	1 000 $	1	1	1	1	1	1	1	1	1	1	1
Physiological Monitor	20 000 $				1		1	1				
Vital Signs Monitor, Recusive	4 000 $	1	1	1		1						
Multi-channel volumetric pump	8 500 $							1		1		
Single channel volumetric pump	4 500 $	1		1	1	1	1	1	1		1	
IV Pole	200 $	1	1	1	1	1	1	1	1	1	1	1
Wall-Mount Succion	300 $	1		1	1	1	1	1	1	1	1	1
Medical air	200 $	1		1	1	1	1	1	1	1	1	1
Nurse Call Button	500 $	1	1	1	1	1	1	1	1	1	1	1
Internet Access	1 000 $	1	1	1	1	1					1	
Patient control by PDA	2 000 $	1		1	1	1			1	1	1	
Entertainment via PDA Control	1 000 $	1	1	1	1	1				1	1	
Pediatric [full side rail] vs adult [four half-rails] Setup	2 000 $	1		1	1	1						
Speaking / Answering the patient from the nursing station	1 000 $	1	1	1	1	1		1	1	1	1	
Family Speaking / Answering the patient	500 $	1	1	1	1	1				1	1	
Motorized movements	1 500 $	1	1	1	1	1	1	1	1	1	1	
Electronic containment in the bed [exit management]	2 000 $		1									
Voice Commend	1 000 $				1	1		1				
Four wheel braking	200 $	1	1	1	1	1	1	1	1	1	1	1
Pre-programmed Bed Exit Control	1 000 $	1		1	1	1		1				
Pre-programmed seating control	500 $	1	1	1	1	1		1				
Pre-programmed control to extend the bed [i.e. CPR Mode]	500 $	1	1	1	1	1	1	1	1	1	1	
USB port for custom music playback	500 $	1	1	1	1	1		1	1	1	1	
USB port for recharging	200 $	1		1	1	1				1	1	1
Connection for Headset with microphone	500 $	1	1	1	1	1		1	1	1	1	
Antistatic to the wheels	500 $	1	1	1	1	1	1	1	1	1	1	
Dome for patient thermalization and insulation	5 000 $			1	1	1		1	1		1	
Battery shelf life indicator	500 $	1	1	1	1	1	1	1	1	1	1	1
Geographic location	1 000 $											1
Hospital Map and Stretcher Circuit	2 000 $											1
Closest available storage space	2 000 $											1
Proposed Maximal List Price [1/2 of the value of the combined devices]		**18 800 $**	**15 200 $**	**22 050 $**	**28 550 $**	**20 050 $**	**21 200 $**	**33 450 $**	**14 950 $**	**15 300 $**	**16 300 $**	**6 050 $**

DISCUSSION

In this article, we proposed to revisit the current approach of patient bedside during his episode of care, whatever the mission of the care unit.

We are aware that certain technological aspects may be difficult to implement because of the current level of technological advancement. However, we believe that if the medical industry's will is there and the approach becomes cost-effective, an infusion pump could be part of the bed and monitored or controlled directly via the bedside display. It would also be the case for the history of medication combined with the evolution of the general state of the patient during his stay. It would thus be possible to better gauge the effectiveness of the therapeutic means used and adjust them if necessary. To better report the actual times when medication was delivered to the patient, it is essential to document the patient record from the bedside. The patient now seems to be the only person best informed of the medical care and follow-up he has received. His memory may fail. With the technology we propose, it would be the bed that would report all interventions received by the patient in its history accessible at all times to the bedside and to the nursing station. This would be more accurate and would eliminate the risk of under-dose or involuntary overdose while providing better planning for future care.

With a unique IP addressing of each bed, patients can communicate with their families via the bed; there would be no need for a telephone at each bedside.

If you find the design too avant-garde, be indulgent. I had these ideas when I was on a hospital bed, surrounded by pain. What is important to remember at this stage is the integrated and autonomous intelligent bed concept for the nursing episode to the patient. No partial or total reproduction is allowed without my formal agreement.

CONCLUSION

The aim of this study is to suggest a new approach to the organization of medical devices around the patient in a vision of efficiency and ergonomics.

We hope that the medical community will welcome this concept and that the medical industry will follow in the years to come, all to make the patient's stay more user-friendly and better document it.

AKNOWLEDGMENTS

I thank the medical and clinical staff of the brief hospitalization unit at the St-Eustache Hospital who took care of my health between Sunday, March 27, and Sunday, April 3, 2016. Their professionalism inspired me.

The nurses, auxiliary nurses and attendants of the electrophysiology unit at the Sacré-Cœur Hospital in Montreal, enabled me, as of room 493-1, to confirm my vision and to adjust the technological approaches between December 5 and 11, 2016.

ABBREVIATIONS

BMI : Body mass index

CPR: Cardiopulmonary resuscitation

ICU : Intensive Care Unit

IP : Internet protocol

IV : Intravenous

PDA: Personal Digital Assistant.