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Research Article

Intensive Care Unit Scoring Automation System and It's Application

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Abstract

Objective

This study, which contains a system design, enables intensive care unit patients scoring automatically. Developed system is also monitoring the obtained data. This system helps the doctor for evaluation of the patient's prognoses immediately.

Material & Methods

This work includes intensive care supporting system. Apache-II intensive care scoring method was used in this study.

Results

As a result of the study, decision support system helps doctors and the medical personals in the intensive care unit for instant intensive care scoring calculation. The patients prognosis (rather the state of the patient going well or not) can instantly be assessed by using this system.

Conclusions

The system has reached the aim of calculating a state of the patient in seconds by using results of the instantaneous data taken from Ethernet cable. By using the system expected mortality rate quickness is faster than manual calculation about 33% without laboratory automation and 89% by using laboratory automation adapted system.

Keywords: Intensive Care Unit; Severity of Illness Scoring Systems

Introduction

In the last thirty years, numerous scoring system has been developed and widely used in intensive care practice [1, 2]. Scoring system for a single patient or group for the prognosis prediction, which evaluates the performance of the intensive care unit and this system is recommended for clinical trials by doctors. Scoring systems have also been created for often used to determine the seriousness of the general adult diseases [3].

Proposed revised system for each variable, which was compared with the original Apache system and reflects the physiological deterioration in the vital organs, was found as a result of the low number of variables twenty [4].

When the parameters were decreased, which parameters are the serum glucose level, serum albumin level, central venous pressure and urinary output, were determined by using very little changes in their role and during their treatment the outcome variables were determined as more affected [7].

Material and Methods

This study was partially supported by the program of the TUBITAK 1507 (The Scientific & Technological Research Council of Turkey). This study run on a PC with an Intel, Duo CPU 3.20 GHz, 4GB of RAM machine and yielded the results by using Windows 7 operating system. ASP.NET and C# in Visual Studio are used under the study.

In this system some hardware equipment are used such as; patient monitor, database system for storing data, switch for the local connection between server and monitor, CAT5 Ethernet cables, Ethernet converter, RJ-45 plug connection and PC.

The Patient Monitor which has belong to PETAŞ company and the most current model of "KMA 900 " were used in the study. The monitor has Ethernet port, two USB 2.0 ports, one VGA port, one RS232 serial data port, IABP (ANALOG & IBP ECG) data point, Power supply input (100-240V 50/60 Hz) and sockets from which the parameters of the patient: T1 and T2 (Body Temperature), IBP (invasive blood pressure), NIBP (non-invasive blood pressure), SpO2 (oxygen saturation) and ECG(electrocardiogram).

User interface shows data and calculate APACHE-II scoring by using Table 1. All data come from the patient monitor and the others can be entered manually by the physician.

For the obtained patients data APACHE points could be calculated in equation below as the sum of the thirteen parameters in Table 1 (Eq. 1.),

Total Acute Physiology Score = 15- Real GCS (Eq. 1.)

Table 1.

Physiological values	High Rate Values					Low Rate Values				
	+4	+3	+2	+1	0	+1	+2	+3	+4	Score
Temp (rectal ^{0}C)	≥41	39-40.9		38.5-38.9	36-38.4	34-35.9	32-33.9	30-31.9	≤29.9	
Mean arterial pressure (mmHg)	≥160	130-159	110-129		70-109		50-69	40-54	≤49	
Heart rate (pulse/min)	≥180	140-179	110-139		70-109		55-69	40-54	≤39	
Respiration rate (/min) (spontan/mechanic)	≥50	35-49		25-34	12-24	10-11	6-9		≤5	
FiO_2≥0.5 so the Alveolar arterial gradient DO_2	≥500	350-499	200-349		<200					
FiO_2<0.5 so PaO_2					>70	61-70		55-60	<55	
Arterial pH (choice)	≥7.7	7.6-7.69		7.5-7.59	7.33-7.49		7.25-7.32	7.15-7.24	<7.15	
Venous HCO_3 (mEq/L)	≥52	41-51.9		32-40.9	22-31.9		18-21.9	15-17.9	<15	
Sodium (mEq/L)	≥180	160-179	155-159	150-154	130-149		120-129	111-119	<110	
Potassium (mEq/L)	≥7	6-6.9		5.5-5.9	3.5-5.4	3-3.4	2.5-2.9		<2.5	
Serum creatinine (mg/dL) Acute renal failure => x 2	≥3.5	2-3.4	1.5-1.9		0.6-1.4		<0.6			
Hematocrit (%)	≥60		50-50.9	46-49.9	30-45.9		20.-29.9		<20	
Leukocyte (/mm^3 x 1000)	≥40		20-39.9	15-19.9	3-14.9		1-2.9		<1	
Glasgow Coma score (GCS)										

Total APACHE II Score is revised by using age score, chronic health score. Age Score and Chronic health score calculations are shown in Eq. 2. and Eq. 3.

Age Score (year): <44=0, 45-54= 2 point, 55-64=3, 65-74= 5 point, ≥75=6 (Eq. 2.)

Chronic health scores: in the past serious organ system failure or if immunosuppression. Immunosuppression can be categorized as;

- Hepatic: With biopsy proven cirrhosis, portal hypertension, associated gastrointestinal bleeding, liver failure, Encephalopathy, coma,
- Cardiovascular: Angina and cardiac symptoms at rest,
- Respiratory: Activity restrictive chronic restrictive, obstructive disease, Chronic hypoxia, hypercapnia, secondary polycythemia, severe pulmonary hypertension, mechanical ventilation,
- Renal: chronic hemodialysis, peritoneal dialysis, the immunosuppression: the immunosuppressant, chemotherapy, radiotherapy, intake of high doses of steroids (leukemia, lymphoma, AIDS)

For the defined symptoms, it has not operated or were operat-

ed on emergency patients =5 point, b) Elective postoperative patients =2 point

(Eq. 3.)

Total APACHE II Score is sum of the Eq. 1., Eq. 2. and Eq. 3.

At the first stage of the study, data were transferred to the database of patient monitors automated scoring module. At the next stage, the data is taken from the database and transferred to the scoring system. The others are entered manually then intensive care scoring module makes necessary calculations.

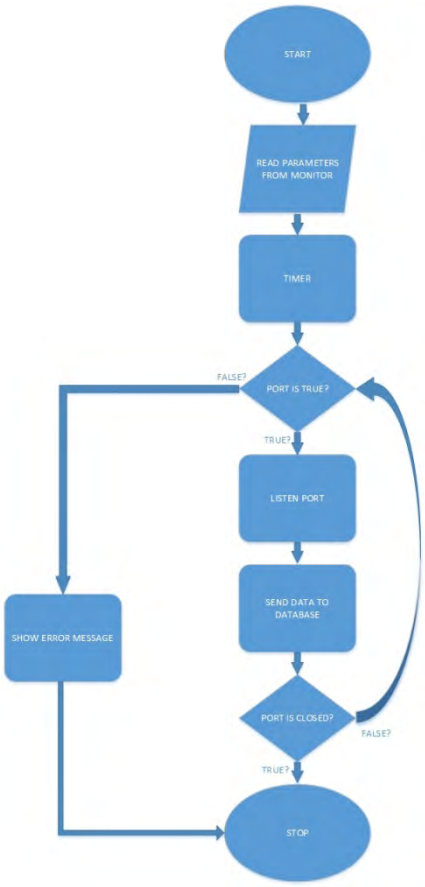

Figure 1. Flowchart of the Data Flow from the Monitor.

There were some parameters can be taken from monitor such as; EKG pulse, IBP1 Systolic pressure (mmHg), IBP1 Average pressure (mmHg), IBP1 Diastolic pressure (mmHg), IBP2 Systolic pressure (mmHg), IBP2 Average pressure (mmHg), IBP2 Diastolic pressure (mmHg), NIBP Systolic pressure (mmHg), NIBP Diastolic pressure (mmHg), 1. Obtaining these parameters UDP (User Datagram Protocol) is used. By using this protocol all data could be taken from RJ-45 jack. Timer interrupt was used for listening port and the information is received per minute. If port value is true, port will be listened periodically. After this procedure, all parameters will sent database for APACHE scoring. Port will be closed after saving monitor parameters. All procedures are shown in Figure 1 as the flowchart.

Results & Conclusions

Obtaining Parameters from Monitor Interface Design:

Touch panels are designed to be used by medical personnel on the basis of International Apache 2 Scoring System Interface. Windows Operating System in accordance with the .NET Framework environment such as; Asp.NET, Javascript, CSS, HTML5. User interface was also prepared using the bootstrap interface structures for fast usage, which was taken to be as simple and understandable usage.

All APACHE-II data could be seen from this interface and whether any need, doctor could change parameters from this interface shown in Figure 2.

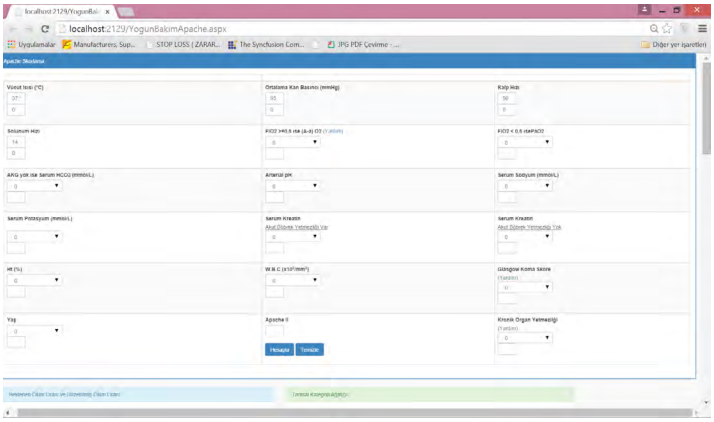

Figure 2. Automated APACHE Scoring System Interface.

Apache Scoring

For automatizing intensive care scoring some data could be taken from monitor. Data which can be taken from monitor are EKG pulse, IBP1 Systolic pressure (mmHg), IBP1 Average pressure (mmHg), IBP1 Diastolic pressure (mmHg), IBP2 Systolic pressure (mmHg), IBP2 Average pressure (mmHg), IBP2 Diastolic pressure (mmHg), NIBP Systolic pressure (mmHg), NIBP Diastolic pressure (mmHg), 1. Channel Temperature measurement results (Celcius), 2. Channel Temperature measurement results (Celcius), O_2 saturation (%), Respiratory (per min), End Tidal CO_2, Inspired CO_2 and Respiratory obtained from CO_2 (per min).

In addition to these data some laboratory data and other medical data must be added for scoring such as: FiO_2>= 0,5 if it so (A-a) O_2, FiO_2 < 0,5 if it so PaO_2, AKG absent Serum HCO_3^-(mmol/L), Arterial pH, Serum Sodium (mmol/L), Serum Potassium (mmol/L), Serum Creatine: If there is Acute Renal Failure, Serum Creatine: If None-Acute Renal Failure, Ht (%), W.B.C (x10^3/ mm^3), Glasgow Coma Score, Age and Chronic organ failure.

When all data are obtained scoring can be calculated by using user interface. A revised data obtained in this study are record-

ed in the second instant database. The data is transferred to a scoring system in every per minutes. With this system, physicians can decide how critical the patient's condition. Proposed system helps the physician by using this scoring module. For system success this module has been tested by Assoc. Dr. Yücel BALBAY (Intensive Care Cardiology Specialist) at the High Specialized Hospital in Turkey. In addition, this system allows the recovery time of the patient follow-up, physicians will be able to intervene more quickly to patients and all critical data is expected to decrease confusion data it is in the hands of physicians.

The expected mortality rate will be calculated after all APACHE parameters will be completed by doctor shown in Figure 3. By using this automated APACHE scoring expected mortality rate is getting faster than manual calculation.

For the system time improvement calculation, the formula can be used in Eq.4 below;

$$T = \frac{Automated\ Parameter Number}{Total\ Number of\ the\ APACHE\ Parameters} \times 100\% \quad \text{(Eq.4)}$$

Because APACHE scoring need 18 parameter for calculation. By using this interface six parameters are taken from ICU monitor. If the hospital has no laboratory automation system this interface getting 33.3% faster than manual calculation. If the hospital has laboratory automation system this interface just need Glasgow Scoring (Coma scoring and this must be done by doctor) and time improvement is calculated as 88%.

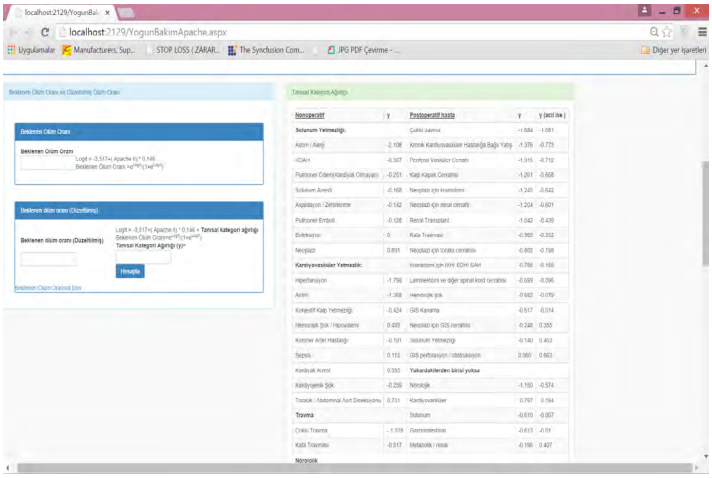

Figure 3. Automated APACHE Scoring System Mortality Result.

Competing Interests

The authors declare that they have no competing interests.

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