European Journal of Cardio-thoracic Surgery 27 (2005) 266–269

EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY

www.elsevier.com/locate/ejcts

Cybertools improve reaction time in open heart surgery☆

Antoine Beuchat*, Steven Taub, Jean-Damien Saby, Vincent Dierick, Gianmarco Codeluppi, Antonio F. Corno, Ludwig K. von Segesser

Department of Cardio-vascular Surgery, Centre Hospitalier Universitaire Vaudois (CHUV), Rue du Bugnon 46, Lausanne CH-1011, Switzerland

Received 14 September 2004; received in revised form 27 October 2004; accepted 28 October 2004; Available online 15 December 2004

Abstract

Objective: Head-up displays allow the surgeons to simultaneously view the patient and the patient's vital parameters (ECG, blood pressure, etc.) using vision-through over a wireless net, potentially enhancing the speed, accuracy and safety of surgical decisions. The aim was to assess surgical reaction time to AFIB, bigeminy, trigeminy, VTACH, and VFIB and concentration during a surgical intervention comparing standard and cyber tools monitoring. **Methods**: Using a patient simulator for beating heart surgery able to emulate heart signals and motion (arrhythmias) a group of surgeons performed coronary bypass procedures. Measurements of reaction time, efficiency of the surgeon, time elapsed to display a coronary angiography in a realistic surgical environment were taken. **Results**: The duration to accomplish the experiment is not different between groups (cyber vs. standard) reaction times, however, are significantly decreased for cyber by a mean of 33%. There is also a measured time difference for displaying a coronary angiography within the head-up display as compared to a remote console. **Conclusions**: During surgery, modern cyber tools allow for significant improvements of reaction time and concentration due to real time access to vital information.

Keywords: Cybertools; Head-up display; Reaction time improvement; Display of various sources of information; Increase patient safety; Surgical decisions

1. Introduction

Presently in the operating theater, the vital signs of the patient as (ECG, EEG, Sv02, blood pressure, etc.), necessary throughout operation, are displayed on a remote screen outside of the visual field of the surgeon, furthermore monitors present an influx of numerical data that can overwhelm [6].

If nobody communicates these parameters to the surgeon, he has to switch his attention to the remote screen [3]. Cyber tools allow the surgeons to simultaneously view the patient and the patient's vital parameters selecting useful data using see-through vision glasses, potentially enhancing the speed, accuracy and safety of surgical decisions.

In this study the utility of a light wearable head-up display (HUD) will be evaluated by comparing it with that of the current monitor. Some evaluations, like surgical reaction time and concentration, will be quantified and others more subjective related to the users of the HUD will be discussed.

2. Materials and methods

2.1. Head-up display and wireless system

The HUD is a specialized audio video headset from Sony Glasstron (Fig. 1) that covers the eyes with wrap-around goggles, featuring images in the size of a 52-in. screen. Built in magnesium alloy, the headset has a weight of 180 g. The two LCD panels, which display 180,000 pixels each, measure 0.7 in. A special shutter can be opened and closed, which lets users see through to the outside environment or maintain an immersion display.

The portable device is coupled to a nearby wireless emitter receiver (Grandtec Ultimate Wireless) over 2.4 GHz the industrial, scientific, and medical (ISM) band. This module is able to transmit several inputs and to convert them to a video signal for the purpose of wireless transmission. The effect of electromagnetic compatibility (EMC) on electronic instruments used in this experience was negligible [1,4].

This intermediate prototype shows the usefulness of this experiment but it is not a real industrial product one could think of. An industrial cyber tool would be lighter but substantially more expensive.

2.2. Connexions

The input was an XGA signal providing clinical information graphically and the output was a Pal signal. Connexion of

☆ Presented at the joint 18th Annual Meeting of the European Association for Cardio-thoracic Surgery and the 12th Annual Meeting of the European Society of Thoracic Surgeons, Leipzig, Germany, September 12-15, 2004.

*Corresponding author. Tel.: +41 21 314 22 47; fax: +41 21 314 22 79.
E-mail address: abeuchat@storebyte.com (A. Beuchat).

1010-7940/$ - see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.ejcts.2004.10.051

Fig. 1. Sony Glasstron PLM-A55.

the head-up display and the wireless system are schematically represented in Fig. 2. Technical data are detailed in Table 1.

2.3. Patient simulator

A thoracic replica in polyurethane, already described by von Segesser et al. [2], was used to simulate lifelike beating heart movements in a patient (Fig. 3). To simulate the heart signals and arrhythmias an electronic patient simulator from Dynatech (model 214A) was used.

2.4. Methods

The realistic experiment was performed in an operating theater suite in the Research Laboratory of the *Department of Cardio-vascular Surgery (CHUV-CH)*. The HUD described above was used by four surgeons to assess their quantitative efficiency in a surgical standardized intervention. This intervention consisted of a partial coronary bypass on the patient simulator able to produce arrhythmias artificially. During the intervention the mannequin controlled by an external engineer simulated several cardiac complications among which were: atrial fibrillation (AFIB), bigeminy, trigeminy, ventricular tachycardia (VTACH) and ventricular fibrillation (VFIB).

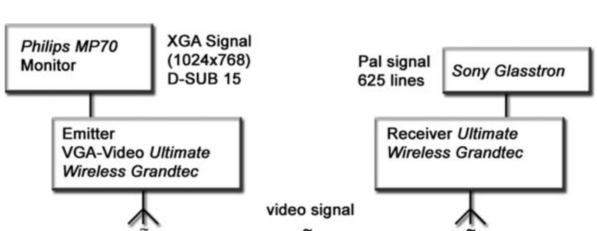

Fig. 2. Diagram bloc.

Table 1
Technical data

HUD	
Input	PAL colour/S-Video
Resolution	800×225 (s-video)
Refresh rate	>50 Hz
Dimensions	17×5×5.5 cm (display)
	5×4×10 cm (power supply box)
Weight	180 g (display)
	130 g (power supply box)
Battery lifetime	~7 h
Trans-receiver	
Input	VGA displays mode
Net	2.4 GHz wireless radio transmission
Distance	30 m (indoor)
Dimensions	13×12×2.5 cm
Weight	170 g
Battery lifetime	~4 h

Four experiments per surgeon were taken. On two of them surgeons could observe asystoles using an electrocardiogram remote monitor (conventional display) attached to the simulator. A HUD was used for the remaining two trials as wearable monitor. The order of the four experiments described above was chosen in a random way to eliminate the effect of improvement by training.

The following measurements were taken during each experiment with and without wearing a HUD.

- reaction time of the surgeon to the various abnormal vital signs
- time needed by the surgeon to conclude the operation
- number of points of suture
- number of times per minute the bearer of glasses had to switch his attention away from the operative field
- time necessary to display a coronary angiography

In order to make a complete study of our prototype, the tiredness and the feeling of the surgeons were also reported.

2.5. Statistics

Values recorded during the coronary bypass with a head-up display were compared with those recorded with standard

Fig. 3. Patient simulator.

display using a *t*-Student model. Data collection and statistical analysis were carried out using R (GNU project) software. All factors were assessed with the statistical significance ($P<0.05$).

3. Results

The duration to accomplish the experiment and the number of suture points were not significantly different between groups; nevertheless the average with the HUD remains lower. We noticed a real difference for the reaction time for almost all anomalies (Fig. 4). The reaction time with the HUD was almost half compared to the one of conventional monitoring, without taking into account an apparent difference in the quality of the operation. The reaction time for VFIB is not significant; indeed an isolated abnormal measurement increases the mean value of our results.

The abnormal vital signs of the patient were not always detected without the port of the HUD whereas by using it they were always detected.

Three hundred seconds to view a coronary angiography without HUD were measured, for viewing it the surgeon must generally leave the operating theater, thus he is obliged to sterilize himself again and to return in the room, the protocol dictates one duration of 5 min of preparations. The above results are summarized in Table 2.

4. Discussion

To evaluate the efficiency of our prototype we have also to consider the opinion of the surgeon and not only the reaction time results. The ability of the surgeon can be measured by time necessary to achieve a controlled task, as well as the facility of its achievement and its induced tiredness.

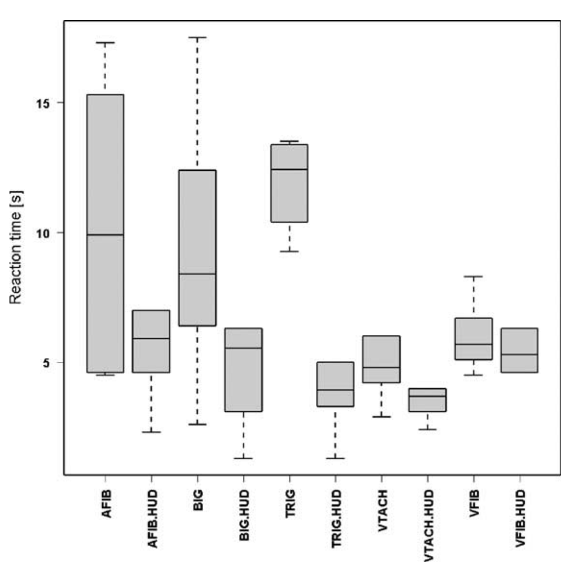

Fig. 4. Box plot of reaction time difference between groups (HUD vs. standard).

Table 2
Results table

	Monitor	Head-up display	*P*-value
Duration to accomplish experiment (min)	8.7±2.2	7.44±2.7	0.085 NS
Mean reaction time to AFIB (s)	13.6±6.2	6.7±4.1	**0.051**
Mean reaction time to bigeminy (s)	9.3±5.1	5.7±3.8	**0.044**
Mean reaction time to trigeminy (s)	12±2.1	4.6±2.8	**0.01**
Mean reaction time to VTACH (s)	5.3+2.1	3.7±1.1	**0.036**
Mean reaction time to VFIB (s)	6±1.3	6.9±3.2	0.944 NS
Head movement (shifted attention)	11.5	0	**0**
Time elapsed to display coronary (s)	300±10	2.5±0.5	**0**
Number of suture points	10.3±2.4	11.3±1.6	0.844 NS

Experiments do not demonstrate a difference in term of time necessary to achieve the intervention. On the other hand a larger attention was directed to the heart anomalies, having kept the same protocol and the same results. Concentration was focused on the simulator.

Tiredness could not be quantified with the HUD but according to surgeons after 1 h they could feel an additional physical tiredness. This problem can be solved as the prototype HUD weight was not weight optimized; in fact we were slowed down by 'economics'.

4.1. Wireless system

Eliminating the need for wired connection with the HUD allow, otherwise surgeons to be mobile, to couple other HUD in the operating room with the same infrastructure, which shortens the retrieval time for recovering vital information.

The wireless system operates at 2.4 GHz which may pose a risk on interference with some medical devices. However, studies have shown that a WLAN (operates at the same frequency) can be acceptable for use in hospitals [1,5]. Further studies are needed to clearly address the possibility.

4.2. Transmission

Multiple sources connected to the transmitter (including databases of the patients or any electronic document) are an additional advantage of the use of a HUD. Use of the HUD can be conceived for magnification instead of conventional lens attached to the glasses.

4.3. Limitations

Our study is limited by factors which may affect our own analysis, the monitoring must always be used in conjunction with careful clinical observation by the anaesthetist, surgeons in our case were alone for the observation. The cardiac anomalies are noticed more easily on the patient than on the simulator.

In conclusion, during surgery, modern cyber tools allow significant improvement of reaction time and concentration due to real time access to vital information, which is traditionally displayed on remote screens. Introduction of such equipment into routine clinical practice has the potential to increase patient safety and ultimately to improve outcome.

Acknowledgements

We would like to acknowledge the co-operation given to us by all the members of Lifesight (http://www.lifesight.org) which purpose is to link actual and future cyber tools users in medical applications and all volunteers Cardiac Surgeons.

References

[1] Tan KS, Hinberg I. Effects of a wireless local area network (LAN) system, a telemetry system, and electrosurgical devices on medical devices in a hospital environment. Biomed Instrum Technol 2000;34(2):115–8.

[2] Von Segesser LK, Westaby S, Pomar J, Loisance D, Groscurh P, Turina M. Less invasive aortic valve surgery: rationale and technique. Eur J Cardiovasc Surg 1999;15:781–5.

[3] Von Segesser LK. Video-on-Command for thoracic and cardiovascular surgery. Eur J Cardiovasc Surg 2003;24:473–4.

[4] Wallin MKEB, Wajntraub S. Evaluation of Bluetooth as a replacement for cables in intensive care and surgery. Anesth Analg 2004;98:763–7.

[5] Watanabe A, Sugimoto M, Ohshima T, Matsubara K, Yamashita M, Nakayama K, Kojima K. Influence of electromagnetic waves on portable electronic instruments in medicine. Nippon Hoshasen Gijutsu Gakkai Zasshi 2002;58(7):948–56.

[6] Weiss YG, Maliar A, Eidelman LA, Berlatzky Y, Hanson 3rd CW, Deutschman CS, Zajicek G. Computer assisted physiologic monitoring and stability assessment in vascular surgical patients undergoing general anesthesia—preliminary data. J Clin Monit Comput 2000;16(2):107–13.