Use of an Extracorporeal Circulation Workstation During the Routine Care of Cardiac Patients

D. Gaillard, MD, C. Barraud, CCP, O. Bical, MD, L. DeToni, CCP, L.S. Montejo, MD, A. Vanetti, MD

Hospital St. Joseph
Paris, France

Keywords: ECC records, ECC workstation, computer applications

Abstract

In this presentation, we present a computerized system which acquires, stores and processes all parameters currently measured during heart surgery.

The aim of this computerized system is based on:
- continuous acquisition and processing of patient and ECC data
- user adaptability of the system to his or her requirements
- user-friendliness
- adaptability to all operating theater equipment.

The hardware includes an IBM PS/2, with a color screen and an HP laser printer.

This computer can receive seven different monitors. The incoming values are displayed either instantaneously or as averages. The results can be displayed either in color graphic form and updated automatically, or in tables.

All parameters commonly measured in the operating room at present can be recorded by the software; for example, all arterial and venous pressures, venous and arterial saturation, five different temperatures, cardiac output, ST segment level, pump flow rate, arterial and venous blood gases in continuous with CDI 300.

With any parameters, computed data, such as vascular resistances, O_2 consumption are also obtained on a continuous basis.

It is a powerful instrument, not only for the whole surgical team because of its multiple personalization and interfacing capability, but also for use in research.

Introduction

The recent technological advances in monitoring, especially in the field of cardiac surgery, have notably increased the number of variables that are to be followed during a procedure. Although this evolution has no doubt contributed to the better care that we can now provide for our patients, in some instances it has complicated the way that we must deal with this new surge of information.

A computer workstation capable of gathering and centralizing any and all information present in an operating room frees its user of the above mentioned constraints and allows him to devote his time fully to the patient, now with a better understanding of his physiopathological status.

Address correspondence to: D. Gaillard, MD, Hospital Saint Joseph, 7 rue Pierre Larousse, 75014, Paris, France.

The use of an ECC workstation seems thus a necessity, so as to better centralize and in some cases, aid in the interpretation of the great amount of information that can be made available to the modern perfusionist.

Unlike others who have developed computer systems for use during ECC which focus on the heart/lung machine, we believe that the pivot for a workstation in this field must be the patient. As a corollary, it is therefore mandatory that any information available to the Anesthesiologists will also be integrated into the ECC workstation.

A Workstation for bypass must therefore:
1. Have high sampling rates (q 2-4 secs) of any information available in the operating room.
2. Work with high speed graphics of any variable.
3. Have centralized alarms or any variable present in the operating suite.
4. Have warnings for the user regarding any malfunctions of monitors or sensors connected to the system.
5. Perform with useful real-time calculations such as SVR or TRO_2.
6. Be customizable on screens, printouts, et cetera.
7. Save its information in files that are easily imported into multiple commercially available programs.
8. Multi-task.
9. Run within a Network.
10. Be integratable to any hospital's information system.

Materials

We have used the following hardware for our ECC workstation:

- IBM PS2 model 70 (INTEL 386 processor at 25 mhz).
- 110 Megabyte Hard Disk.
- Two 8513 Color Monitors (One for anesthesia, and one for the perfusionist).
- Two keyboards.
- Multiple Serial Ports for communication links.

For software we used:
- HMP Sensor (Marquette Elect. ON-GUARD) for Anesthesia.
- HMP Helena (Cobe Laboratories) for ECC.

Article available at https://ject.edpsciences.org or https://doi.org/10.1051/ject/199022S035

These two systems co-exist during the procedure through multitasking.

Finally, all our operating room equipment, including our heart- lung machine, has RS232 serial communications links.

Methods

Diagram 1 displays a clear representation of our operating room. With no special hardware, we can link to our personal computer up to seven different devices via its standard serial ports.

- The Hewlett Packard monitor is our sensor for:
Arterial Pressures
Filling Pressures
Temperatures
Heart Rate

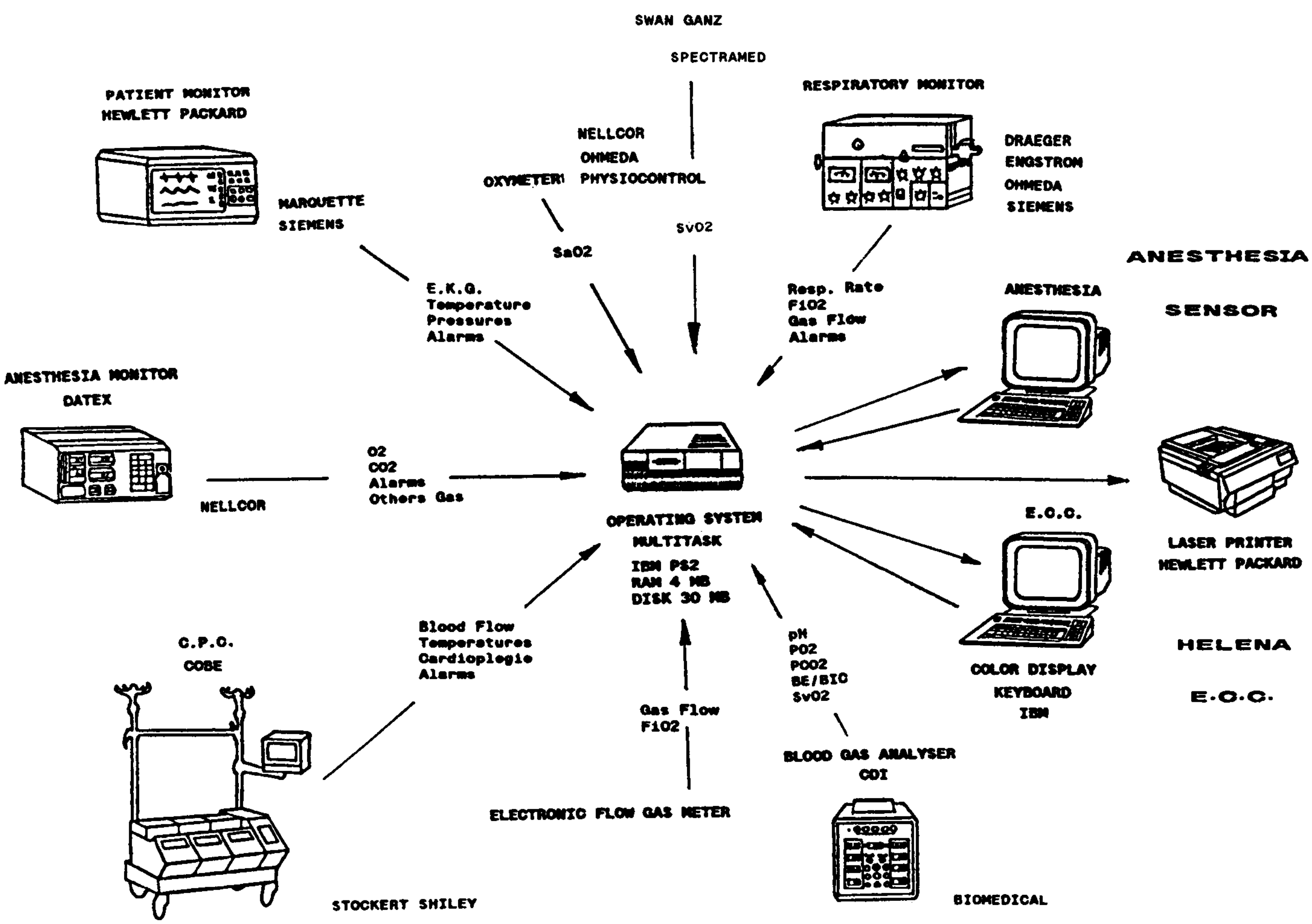
- The Datex Multicap is our sensor for:
$EtCO_2$
EtO_2
Respiratory Rate

- The COBE HLM is our sensor for:
Pump Flow (pulsatile or non-pulsatile)
Temperatures (5 different ones)
Cardioplegia Information
Pressures (ie: before oxygenator, or after it)

- The CDI 300 provides us with:
pH, pCO_2, pO_2 (arterial and venous)
HCO_3
SvO_2

Both the anesthesia and perfusion modules for the software have over 20 different drivers available to communicate with most of the major monitoring manufacturers; thus, we are not limited by our present configuration.

DIAGRAM 1: Devices



System Use

During ECC as well as during the rest of the surgical procedure, all available data is read into the system every 2 to 4 seconds. Thirty simultaneous variables can be read during bypass alone.

The software came with cable descriptions for the monitors and its drivers, and in our case, we had our hospital bio-engineers devise a single data cable which regroups all the information in our setting. This cable then goes through the ceiling of our suite and descends next to the computer's serial ports where it splits up according to how we configured the system during its customization.

After this, we have had no maintenance or communications problems with the devices linked to the system.

Results

The multitasking environment that the system runs under has allowed us the concurrent running of both the anesthesia and ECC modules of the system. One can either run both systems each sharing a portion of the screen, or each one full screen while the other remains operational in background. We have preferred the latter method and have found it extremely easy to go back and forth between them by simply tapping a single switch key. This environment has also allowed us to run concurrently other tasks such as word processing, data base, or even our own BASIC programs developed in our department, while the system is operating and with little system degradation (Figure 1). As an added protection, if at any time we are in another environment and a problem occurs, a bright red window will break through our current task and inform us of the problem.

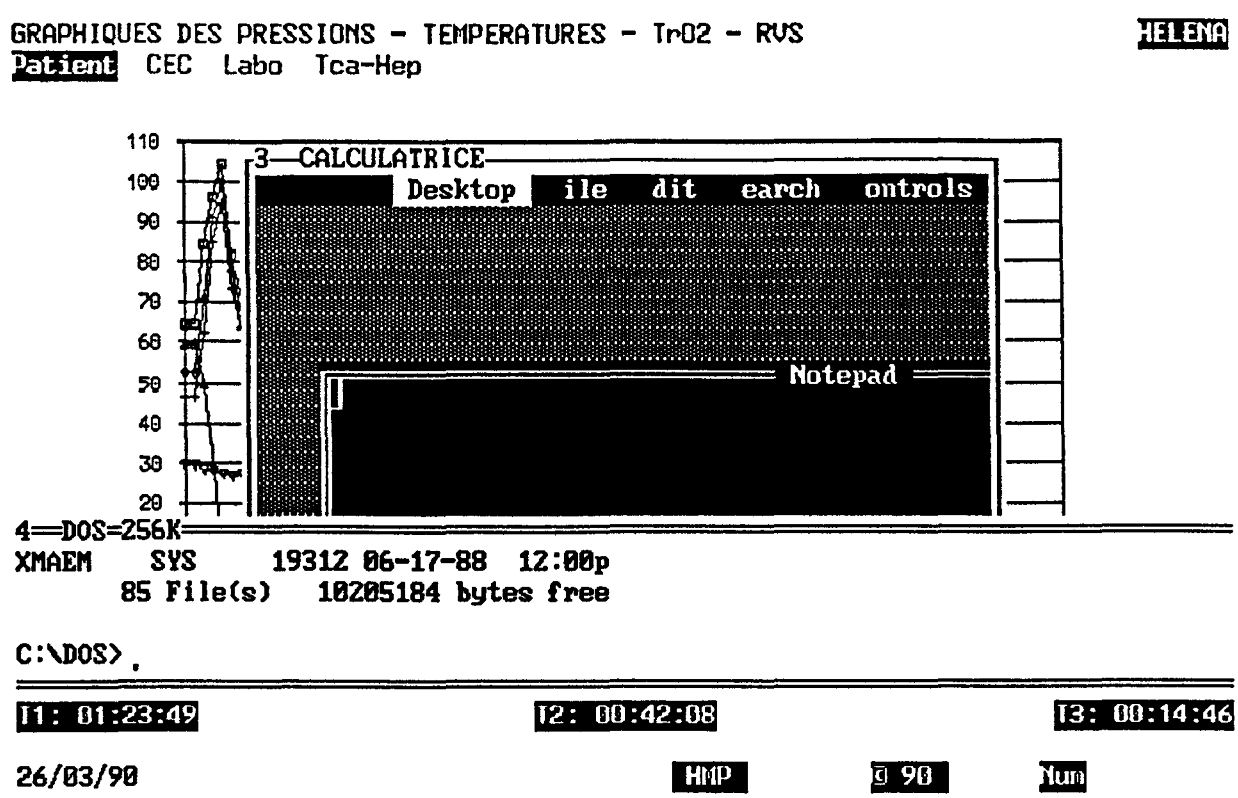
We have used the system's customization utility extensively. The number of customizations that one can create is practically unlimited, and we have found it useful to create different setups for our adult or pediatric cases. The system makes it simple to call up any existing customization.

The software is menu driven, and with its multiple menus there is the initial fear that this will make it difficult and cumbersome to handle. But the system allows one the creation of some 30 macros (quick-keys) which greatly facilitate the use of the program. A macro is simply a series of keystrokes that the system executes and that is user-definable. We have created 26 macros of our own choice for the Helena program, which allow us to move to any area of the system that we have pre-selected with only one keystroke. Our cohorts from anesthesia work with only 10 macros of their own. Moreover, although we do not use this feature, each individual user could have his own set of macros.

Data Acquisition

Figure 2 is a print-screen showing how data can be viewed in a tabular fashion, much like a flowsheet. The left column

FIGURE 1: Multitasking (3 Tasks)



displays the variables that one can review in this window. Other screens regroup laboratory data (Figure 3), or information specific to the heart lung machine (Figure 4).

Systemic Vascular Resistance (SVR) is automatically derived since the system knows both the flow and mean arterial pressure at any given time. Oxygen transfer (TrO_2) is also calculated every 3-4 seconds since the system reads flow and oxygen saturations continuously. (A Hemoglobin value must be keyed in.)

On the right of the screen, imported data is displayed and updated every 2-4 seconds. (Mean Arterial Pressure, Heart Rate, Central Temperature, Pump Flow, SVR, and TrO_2.) This real time data is present at all times, regardless of the screen we are viewing in the system.

Although tabular data is important, we spend more time viewing the system graphics: Figures 5-7 show different print-screens of our system in real-time. Color allows for an easy interpretation of these. Furthermore, any of these graphs can be zoomed to full screen for a more detailed visualization.

At the end of each procedure, a laser quality customizable printout is generated for each of our patients. More importantly, a patient file with all this information is automatically stored on the hard disk of our station (automatic saving to a network server or other storage device is also implemented within the system).

Discussion

Continuous data acquisition with a computer has already been proposed for anesthesia in many publications (1, 3, 4, 9, 11).

Cardiac surgery, with ECC, is the source of many physiopathologic changes which are often poorly grasped due to lack of centralized real time integration.

The perfusionist should devote his full time to taking care of the patient and not to trying to read, interpret, and finally record much of the information now available to him in the Operating Room (3-12).

An ECC workstation not only is able to help in the above situations, but is also the open road towards a more meaningful understanding of bypass since all data can now be automatically recorded. In real time, the new knowledge of SVR and TrO_2 allows us to make more clinically relevant therapeutic decisions (8).

Although some have expressed fear of these "black-box" systems (2), it should be noted that in most cases they are a precious aid when litigation is in question (2, 11, 12). We have found it useful that the system allows us to edit in real time data which may be erroneous due to artifact. At the end of a case though, files are locked both at the workstation and server level if a Local Area Network (LAN) is in place. The ability to review any case in retrospect both in a tabular, as well as in a graphical form (5) has proven of value.

ECC Workstations must be able to adapt themselves easily to different operating rooms within a hospital. Multiple drivers for different configurations in our rooms must be made available, (6-7) and exist with the system we have just described.

Finally, ECC workstations must not be considered as islands of data within a hospital. They must be able to be integrated to a larger network of information where data can be shared and viewed at different levels of a hospital information system. A common data structure must exist for any patients from the moment they enter the heart room, to the moment they return to their wards after leaving the critical care unit.

Conclusions

The system we have just described allows us to automatically acquire almost all measured data present in our operating room today. It is centered around the patient, and its purpose is not solely to print an ECC record or to be a black box (10). Instead, it is a very powerful work tool, a true ECC workstation, which allows us to better care for our patients.

References

1. Beneken, JEW, Blom, JA, Meijler, AP et al. Computerized data acquisition and display in anesthesia. *Computing in Anesthesia and Intensive Care.* 1983; 25-43.
2. Gibbs, RF. The present and future medico-legal importance of record keeping in anesthesia and intensive care : The case for automation. *Journal of Clinical Monitoring.* 1989; 9: 251-255.
3. Gravenstein, JS. The uses of the anesthesia record. *Journal of Clinical Monitoring.* 1989; 9: 256-265.
4. Gravenstein, JS. The automated anesthesia record. *International Journal of Clinical Monitoring and Computing.* 1986; 3: 131-134.
5. Harrison, MJ. Physiological data display during anesthesia. *International Journal of Clinical Monitoring and Computing.* 1986;3: 123-130.
6. Karliczek GF, de Geus, AF, Wiermsa G et al. Carola, a computer system for automatic documentation in anesthesia. *International Journal of Clinical Monitoring and Computing.* 1987; 4: 211-221.
7. Lees DE. Computerized anesthesia records may have drawbacks. *Anesthesiology.* 1985; 63(2): 236-237.
8. Noel, TA. Computerized anesthesia records may be dangerous. *Anesthesiology.* 1986; 64(2): 300.
9. Osswald PM, Winter D, Hartung MJ et al NAPNOS : A semi automatic user friendly anaesthetic record system. *International Journal of Clinical Monitoring and Computing.* 1987; 4: 231-236.
10. Paulsen AW, Knowlton DE, Simpson BR. Computer assisted anesthesia record generation and monitoring enhancement system. Fourth International Symposium. Computing in anesthesia and intensive care, Rotterdam September 2-6, 1986.
11. Rosen AS, Rosenzweig W. Computerized anesthesia record. *Anesthesiology.* 1985; 62(1): 100-101.
12. Sarnat, AJ. Do not fear computerized anesthesia records. *Anesthesiology.* 1986; 65(1): 132.

Questions and Answers

Jeff Riley

Q. Very elegant presentation, quite elaborate. It looks like you decided on a sampling frequency of every 2 minutes. Could you comment on your selection of 2 minutes sampling frequency?

A. Because we were testing the system we wanted an important number of values; but you can use 4 minutes. It depends on what you want to have. If you want many values you have to use 2 minutes.

Q. You said you are seeing better patient care. Have you compared before and after indicators of patient outcome. Are your patients doing better now that you have the computer system?

A. We can always see a patient on an oxygenator during bypass. Oxygen transfer is calculated and the resistance is very important to see if the patient is sleeping or not and what we have to do.

Stammers

Q. You state it's a valuable research tool. Following up on the previous question, have you been able to integrate any statistical analysis of the results generated so far in showing an increased clinical outcome?

A. Testing this system 1½ years and now beginning to test materials with time. The next study will test a new oxygenator with this system.

FIGURE 2: Patient Data (tabular fashion)

HELENA

EDITER DANS CE TABLEAU

Editer Branchement

TEMPS	09:30	09:32	09:34	09:36	09:38	09:40	09:42	09:44	09:46	09:48	09:50
PAM	69	71	72	74	74	75	77	78	79	62	
PSa	71	74	75	76	77	78	80	81	82	64	
PDa	65	68	69	71	72	72	74	74	75	61	
FC	0	0	0	0	0	0	0	0	0	0	
PPM											
PVC											
RVS	1481	1536	1564	1592	1608	1619	1662	1677	1700	1349	
TMP1	28.4	28.3	28.3	28.2	28.2	28.2	28.2	28.2	28.2	28.2	
TMP2											
TMP3		13.0			11.0				11.0		
CAPNO	14.0	19.8	20.4	20.3	20.0	18.1	19.8	19.8	19.8	23.5	
SvO2	94	94	94	88	85	84	84	86	85	84	
SaO2	100	100	100	100	100	100	100	100	100	100	
TrO2	24.1	24.1	24.1	49.8	60.1	64.1	64.1	57.5	61.6	65.6	
Uri											

PT DATA

PAM 96 · FC 0 · Débit 3.5 · TMP1 28.2 · TrO2 171.9 · RVS 1835

T1: 01:23:49 T2: 00:42:08 T3: 00:14:46

26/03/90 09:48 Auto-M A1OFF HMP 90 Num

FIGURE 3: Laboratory Data (tabular fashion)

EDITER DANS CE TABLEAU

HELENA

Editer Résumé Branchement

TEMPS	09:26	09:28	09:30	09:32	09:34	09:36	09:38	09:40	09:42	09:44	09:46
pHa	7.51	7.51	7.51	7.51	7.51	7.50	7.41	7.41	7.41	7.41	7.41
pCO2a	25	25	25	25	25	26	30	30	30	30	30
pO2a	383.4	383.4	383.4	378.9	378.0	318.5	186.0	184.3	182.3	182.0	180.4
pHv	7.58	7.58	7.59	7.59	7.59	7.58	7.50	7.50	7.50	7.50	7.51
pCO2v	26	26	25	25	25	26	45	45	44	43	43
pO2v	61.0	59.6	57.8	57.0	57.0	53.0	52.0	52.0	52.0	54.0	54.0
Bi/BE	20.0	20.0	20.0	20.0	20.0	19.9	19.0	19.0	19.0	19.0	19.0
Hgb										8	
Na+										143.0	
K+										3.8	
Ca++											
Hep										17.0	
TCA										451.0	
HEMATO										23.0	
PROTID										52.0	
HEMOLY										8.0	

LABORATORY

PAM 73 · FC 0 · Débit 3.5 · TMP1 32.5 · TrO2 120.8 · RVS 1395

T1: 01:23:49 T2: 00:42:08 T3: 00:14:46

26/03/90 09:46 Auto-M A1OFF HMP 90 Num

FIGURE 4: Heart Lung Machine Data (tabular fashion)

EDITER DANS LE TABLEAU DES DONNEES PROVENANT DE LA POMPE HELENA

Editer Branchement

FeO2	50	50	50	50	49	50	50	49	49	50	
Fg(Vt)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	
CO2											
GAS-%											
FiO2	65	65	65	65	65	65	65	65	65	65	
Pulsa											
Debit	3.4	3.4	3.5	3.5	3.5	3.3	3.5	3.5	3.5	3.5	
T rv	35.7	35.2	34.5	35.0	36.1	35.6	35.0	34.8	36.2	36.4	
T so	38.3	35.9	35.8	39.2	39.0	36.5	35.8	37.9	40.6	37.4	
P1	208.4	210.7	213.2	209.6	214.0	203.3	208.1	206.5	206.8	209.3	
P2	222.9	226.2	228.9	224.1	228.6	217.7	224.1	221.4	221.2	224.5	
TEMPS	10:06	10:08	10:10	10:12	10:14	10:16	10:18	10:20	10:22	10:24	10:26

BYPASS_INFO

PAM 56 | FC 0 | Débit 3.5 | TMP1 34.6 | TrO2 144.0 | RVS 1070

T1: 01:23:49 T2: 00:42:08 T3: 00:14:46

26/03/90 10:24 Auto-M AlOFF HMP 90 Num

FIGURE 5: Patient Data (graphics)

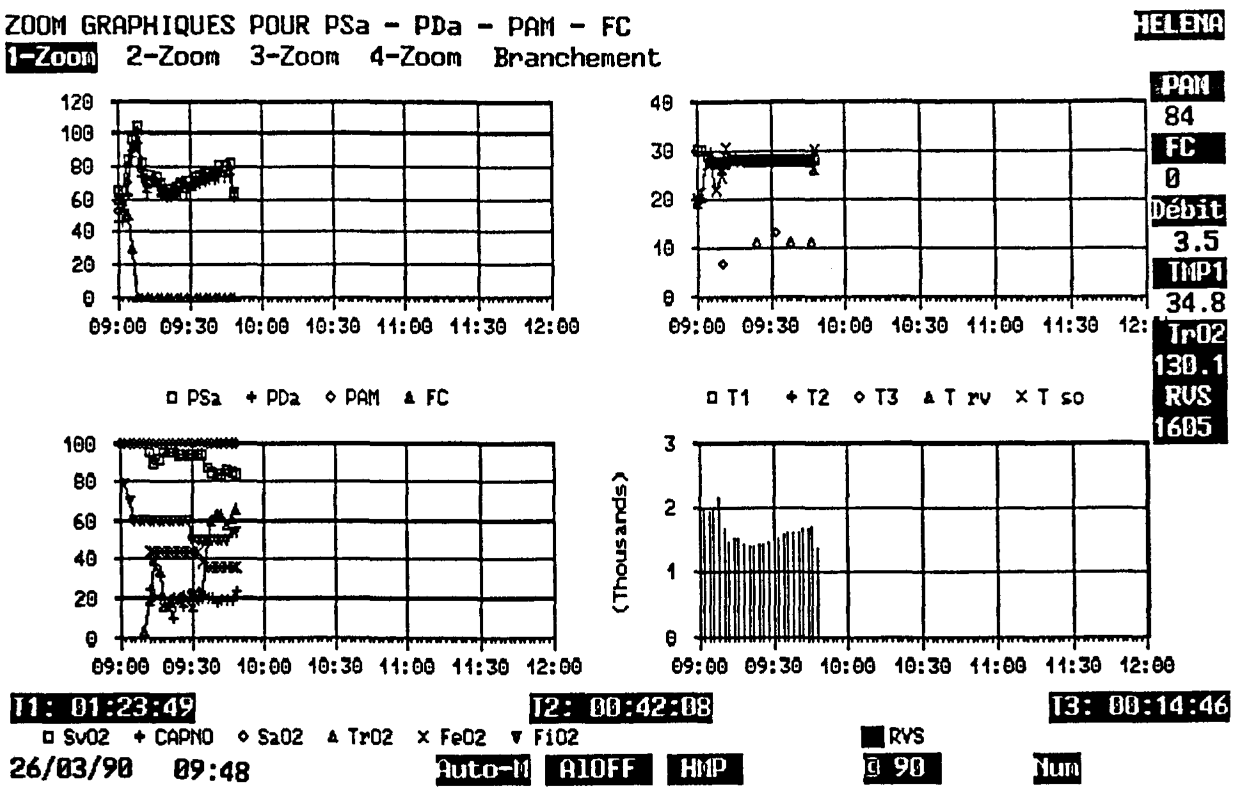


FIGURE 6: Laboratory Data (graphics)

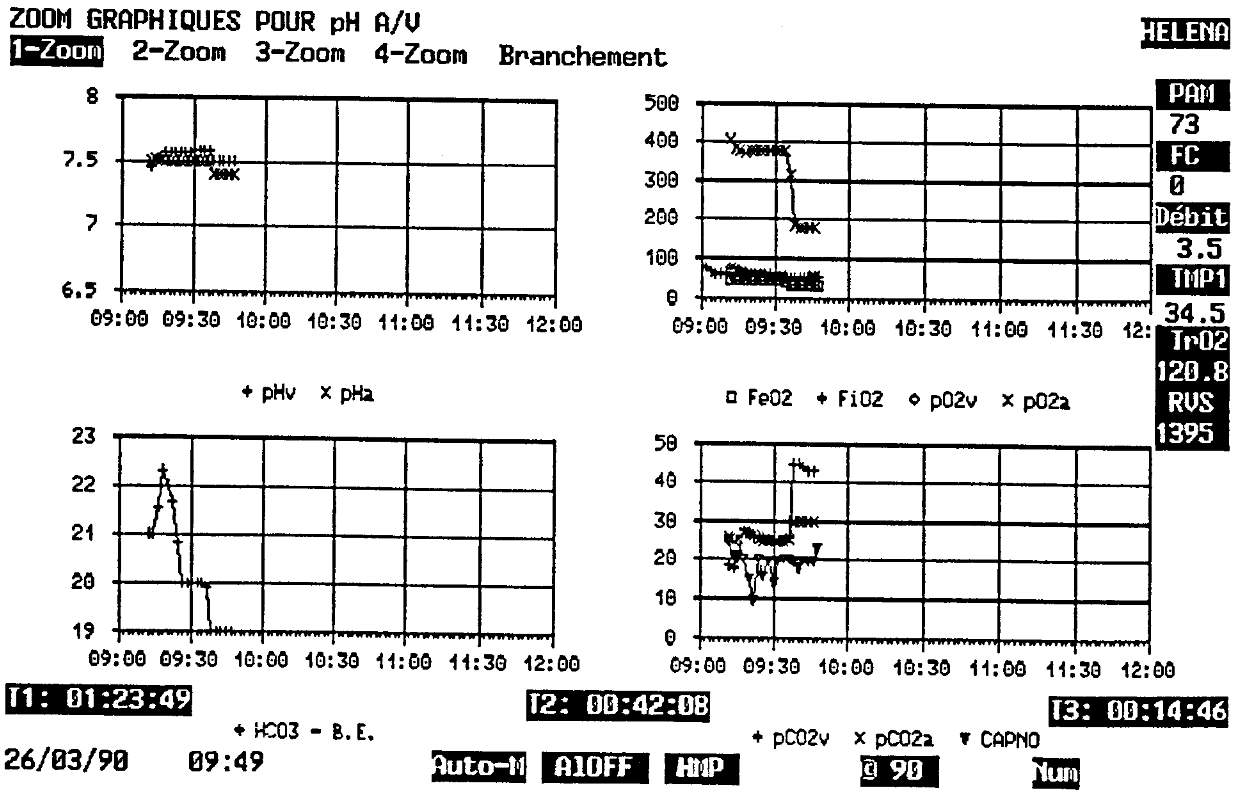


FIGURE 7: Heart Lung Machine Data (graphics)