

A simplified computer program for the performance of physiological calculations from cardiac catheterization data¹

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The authors describe a computer program which can be programmed into a handheld computer with an eight-kilobyte memory. This program would enable a cardiologist to quickly and efficiently analyze hemodynamic data obtained from right and left heart catheterization. Laborious manual calculations are eliminated, and a permanent hard-copy printout is provided.

Index terms: Computers • Heart catheterization • Hemodynamics

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The performance of right and left heart catheterization yields much data which must be analyzed in view of the patient's pathophysiologic problems. Such data analysis usually entails laborious manual calculations by the cardiologist. We describe a computer program which can be used by any clinician, even one who is a tyro to computer operation and programming. Other computer programs have been devised, however, they are more elaborate and thus necessitate the use of tabletop computers which cost more (\$300-\$170,00), entail more elaborate programming, and are not practical for community-based cardiologists.¹⁻⁴ Previous programs for handheld computers have not been dedicated to this specific usage.^{5,6}

Materials and methods

Hemodynamic parameters from right and left heart catheterization are obtained and recorded in standard fashion. Oxygen saturations are measured using standard oximetric

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Fig. 1. Epson HX-20 programmable computer with built-in printer and cassette drive.

instruments. We selected an Epson HX-20 briefcase-sized computer (Fig. 1) for the following reasons:

1. Sixteen-kilobyte random access memory and thirty-two-kilobyte read-only memory,
2. Use of the beginner's all-purpose symbolic instruction code (BASIC),
3. A built-in printer,
4. A built-in cassette drive,
5. Portability and compactness, and
6. Reasonable cost (list price, \$795).

Table 1 lists the formulas used to derive the various calculations. These formulas are standard and can be found in catheterization texts.⁷⁻⁹ Table 2 lists the computer inputs needed to arrive at the final printout. Table 3 lists the derived parameters and their units of measure. Figure 2 is a printout of the actual computer program employed.

Results

Figure 3 shows a case of mitral stenosis, illustrating inputs and data outputs. Figure 4 shows a case involving an atrial septal defect, demonstrating shunt calculations.

Discussion

We believe we have designed a computer program to analyze cardiac catheterization data.

Abbreviations Used in Program:

A\$	Name
B\$	Clinic no.
C\$	Age
D\$	Birth date
T\$	Today's date
HT	Height (cm)
WT	Weight (kg)
S	BSA
SA	Sys. art. sat.
SV	Pulm. art. sat.
SC	SVC sat.
IC	IVC sat.
VS	Pulm. vein sat.
HB	Hemoglobin
R	Heart rate
A	Mean aortic blood pressure
B	Mean pulm. art.
C	PCWP
HC	Oxygen capacity
MV	Mixed venous oxygen sat.
AC	Systemic artery content
PC	Pulm. art. content
MB	Mixed venous content
IV	IVC sat. content
VC	Pulm. vein sat. content
OC	Oxygen consumption
CO	Cardiac output
CI	Cardiac index
V	Stroke volume
F	Stroke volume index
PF	Pulmonary flow
PI	Pulmonary flow index
QPS	QP/QS
RS	Systemic resistance
RP	Total pulm. resistance
RA	Pulm. arteriolar resistance
PLP	Left-to-right %
LP	Left-to-right shunt
PRL	Right-to-left %
RL	Right-to-left shunt
AVA	Aortic valve area
MVA	Mitral valve area
VPL	LVms—left ventricular systolic mean pressure
APS	Aortic ms—aortic systolic mean pressure
SEP	sec/beat systolic ejection period
DFP	sec/beat diastolic filling period
LA	left atrial mean pressure or PCWP
LV	LVdm—measured left ventricular mean diastolic pressure
PA	pO ₂
PV	pvO ₂
WX	CaO ₂ —arterial oxygen content
XW	CVO ₂ —venous oxygen content
RR	A-V O ₂ —arteriovenous oxygen content difference
O	Oxygen delivery to the patient
Z	Direc. var.
L	Loop var.

Table 1. Formulas for derived parameters

$$BSA = 0.0072 \times \text{weight}^{0.425} \times \text{height}^{0.725}$$

$$O_2 \text{ consumption} = CI \times A-V O_2 \text{ difference} \times 10$$

$$O_2 \text{ capacity} = \text{hemoglobin} \times 1.34$$

$$\text{Mixed venous saturation} = \frac{2(\text{SVC saturation}) + (\text{IVC saturation})}{3}$$

$$\text{Cardiac output (systemic flow or } Q_s) = \frac{O_2 \text{ consumption in mL/min}}{(\text{systemic artery content} - \text{mixed venous content}) \times 10}$$

$$O_2 \text{ content} = (\% \text{ saturation} \times O_2 \text{ capacity}) + \text{dissolved oxygen}^*$$

$$\text{Pulmonary flow (} Q_p) = \frac{O_2 \text{ consumption in mL/min}}{(\text{pulmonary vein content})^\dagger - (\text{pulmonary artery content}) \times 10}$$

$$CI = \frac{CO}{BSA}$$

$$PFI = \frac{Q_p}{BSA}$$

$$Q_p/Q_s = \frac{PFI}{CI}$$

$$SVR = \frac{\text{mean arterial pressure}}{CI}$$

$$PVR = \frac{\text{mean pulmonary artery pressure}}{PFI}$$

$$P_aVR = \frac{\text{mean pulmonary artery pressure} - \text{mean wedge pressure}}{PFI}$$

$$\% \text{ left-to-right shunt} = \frac{\text{pulmonary artery saturation} - \text{mixed venous saturation}}{\text{systemic artery saturation} - \text{mixed venous saturation}}$$

$$\% \text{ right-to-left shunt} = \frac{\text{pulmonary venous saturation} - \text{systemic artery saturation}}{\text{pulmonary venous saturation} - \text{mixed venous saturation}}$$

$$\text{Left-to-right shunt in L/min} = \left(\frac{O_2 \text{ consumption}}{[\text{arterial } O_2 \text{ content} - \text{pulmonary artery } O_2 \text{ content}] \times 10} \right) - \left(\frac{O_2 \text{ consumption}}{[\text{arterial } O_2 \text{ content} - \text{RV } O_2 \text{ content}] \times 10} \right)$$

AVA

$$= \frac{\text{cardiac output}}{(\text{systemic ejection period [sec/beats]} \times (\text{heart rate [beat/min]} \times 44.5 \times (\sqrt{\text{mean LV systolic pressure} - \text{mean aortic systolic pressure}})) \times \text{cardiac output}}$$

$$MVA = \frac{\text{diastolic filling period LV}}{K \ddagger \sqrt{\text{left atrial mean pressure} - \text{LV diastolic mean pressure}}}$$

* If 75%–85% saturation, add 0.1; if 85%–95% saturation, add 0.2; if >95% saturation, add 0.3. If O_2 delivery is 40%, add 0.7; if O_2 delivery is 60%, add 1.0; and if O_2 delivery is 100%, add 1.7.

† Same as systemic arterial content.

‡ Use 38 if left atrial pressure was actually measured. Use 31 if PCWP is used.

Whereas most medical computer programs are frustrating for the user because of their complexity, our program is user-friendly and requires no prior computer literacy. This program “leads”

the user to every input. A nonphysician could easily load the program and perform the computations. In addition, our program permits use of a fairly low-memory capacity computer that is,

Table 2. Inputs needed

Name
Clinic number
Age
Birth date
Today's date
Height (cm)
Weight (kg)
Systemic arterial saturation
Pulmonary arterial saturation
Superior vena caval saturation
Inferior vena caval saturation
Pulmonary venous saturation
Hemoglobin
Heart rate
Mean aortic blood pressure
Mean pulmonary artery pressure
Pulmonary capillary wedge pressure
Oxygen administration or not? (If yes, give flow rate %)
Cardiac output or not? (If not, give oxygen consumption)
Hard-copy printout or not?
pO ₂
pVO ₂
LV mean systolic pressure
Systolic ejection period (sec/beat)
Diastolic ejection period (sec/beat)
Left atrial mean pressure (or mean PCWP)
LV diastolic mean pressure

Table 3. Derived parameters

Parameter	Abbreviation	Units
Body surface area	BSA	m ²
Cardiac output	CO	L/min
Cardiac index	CI	L/min/m ²
Stroke volume	SV	mL/beat
Stroke volume index	SVI	mL/beat/m ²
Pulmonary flow	PF	L/min
Pulmonary flow index	PFI	L/min/m ²
Systemic resistance	SVR	U/m ²
Total pulmonary resistance	PVR	U/m ²
Pulmonary arteriolar resistance	PaVR	U/m ²
Aortic valve surface area	AVA	cm ²
Mitral valve surface area	MVA	cm ²
Shunt	Q _p /Q _s	% or L/min/m ²

therefore, easily affordable. There are handheld computers on the market today with eight-kilobyte memory which are less expensive than the Epson HX-20, but they do not have self-contained printers or cassette drives. The built-in printer is an asset in providing a hard-copy printout of the derived parameters which can then become a part of the patient's permanent record. Finally, such a program allows one to make these computations in one-tenth of the time necessary for longhand calculations, thus allowing more time for more important duties.

1 REM COMPUTER PROGRAM FOR THE PERFORMANCE OF PHYSIOLOGIC CALCULATIONS
FOR CARDIAC CATHETERIZATION DATA

```

5 REM PATIENT INFORMATION
10 Input "Name";A$
20 Input "Clinic No.";B$
30 Input "Age";C$
40 Input "Birth Date";D$
50 Input "Today's Date";T$
55 REM Calculations of BSA (S)
60 Input "HT in Cm";HT
70 Input "Wt in Kg";WT
80 S=.0072*HT*.725*WT*.425
85 REM Input parameters
86 REM All O2 Sat, enter in as whole no.
90 Input "Sys. Art Sat";SA
100 SA=SA*.01
110 Input "Pulm. Art Sat";SV
120 SV=SV*.01
130 Input "SVC Sat";SC
140 SC=SC*.01
150 Input "IVC Sat";IC
160 IC=IC*.01
170 Input "Pulm Vein Sat";VS
180 VS=VS*.01
190 Input "Hemoglobin";HB
200 Input "Heart Rate";R
210 Input "Mean Aortic BP";A
220 Input "Mean PA";B
230 Input "PCWP";C
235 REM CLS is used to clear only the LCD screen
240 CLS
250 Print "Are you giving O2
260 Input "Yes=1, No=2";Z:CLS
270 IF Z=1 then 1760
280 Gosub 1470
290 Gosub 2560
300 Print "Do you have a"
310 Print "Cardiac output?"
320 Input "1=yes, 2=no; Z:CLS
330 CLS
340 IF Z=1 then 1350
350 REM Calculation of cardiac output
360 Input "O2 consumption";OC
370 OC = OC*4S
380 CO = OC/((AC-MB)*10)
375 REM Calculations of output parameters
380 CI = CO/S
390 PF = OC/((AC-PC)*10)
400 PI = PF/S
410 V=CO*1000/R
420 F=CI x 1000/R
430 QPS = PI/CI
440 RS = A/CI
450 RP = A/PI
460 RA = (B-C)/PI
470 PLR = (SV-MV)/(SA-MV)
480 PLR = PLR*100
490 CP = OC/S
500 LR = (CP/((AC-PC)*10)) - (CP/((AC-IV)*10))
510 IF SA > .94 then 550
520 PRL = (VS-SA)/(VS-MV)
530 PRL = PRL*100
540 RL = (CP/((AC-PC)*10)) - (CP/((VC-PC)*10))
550 CLS
560 Print "Do you want a"
570 Print "Hardcopy print out"
580 Input "Yes=1, No=2"; Z
590 IF Z = 2 then 2010
600 CLS
605 REM Output parameter print out to microprinter: Lprint is the
code to send the data to printer
610 LPrint "Name";A$
620 LPrint "Clinic No.";B$
630 LPrint "Age";C$
640 LPrint "Birth Date";D$
650 LPrint "Today's Date";T$
660 LPrint "Body surface Area";TAB(8);:LPrintusing
"###.##";S;:LPrint" M^2"
670 LPrint "Cardiac Output";TAB(8);:LPrintusing "###.##";CO;:L print"
1/min"
680 LPrint "Cardiac Index";TAB(8);:LPrintusing "###.##";CI;:L print"
1/min/M^2"
690 LPrint "Stroke Volume";TAB(8);:LPrintusing "###.##";v;:LPrint"
ml/beat"
700 LPrint "Stroke Volume Index";Tab(4);:LPrintusing "###.##";:LPrint"
ml/beat/M^2"
710 LPrint "Pulmonary Flow";Tab(8);:LPrintusing "###.##";PF;:LPrint"
1/min"
720 LPrint "Pulmonary Flow Index";Tab(8);:LPrintusing
"###.##";PI;:LPrint" 1/min/M^2"
730 LPrint "QP/QS";TAB(9);:LPrintusing "###.##";QPS
740 LPrint "Systemic Resistance";Tab(8);:LPrintusing
"###.##";RS;:LPrint" units M^2
750 LPrint "Total Pulm. Res.";TAB(9);:LPrintusing "###.##";RP;:LPrint"
units M^2"
760 LPrint "Pulm. Arteriolar Res.";Tab(9);:LPrintusing
"###.##";RA;:LPrint" units M^2"
770 LPrint "left-to-right %";Tab(8);:L printusing
"###.##";PLR;:LPrint"%
780 LPrint "left-to-right shunt";Tab(8);:L printusing
"###.##";LR;:LPrint" 1/min/M^2"
790 IF SA > .94 then 820
800 LPrint "right-to-left %";Tab(8);:LPrintusing
"###.##";PRL;:LPrint"%
810 LPrint "right-to-left shunt";TAB(8);:L printusing
"###.##";RL;:LPrint" 1/min/M^2"
820 CLS
830 Print "Do you want to do"

```

```

840 Print "Aortic Valve Area?"
850 Input "yes=1, no=2";Z:CLS
860 IF Z=1 Then 1060
870 CLS
880 Print "Do you want to do"
890 Print "Mitral Valve Area?"
900 Input "yes=1, no=2";Z:CLS
910 If Z=1 then 1200
920 Goto 1030
930 CLS
940 Lprint "Aortic Valve Area";Tab(8);:Lprintusing
  "###.##";AVA;:Lprint" cm^2"
950 Goto 870
960 CLS
970 Lprint "Mitral Valve Area";Tab(8);:Lprintusing "###.##";
  MVA;:Lprint" cm^2"
980 CLS
990 Lprint:Lprint
1000 Lprint "Copyright 1984"
1010 Lprint "Schaber/Carangio"
1020 Lprint:Lprint:Lprint:Lprint
1030 Print "Program is over"
1040 Print "Go back to menu"
1050 Print "or type run to start": End
1055 REM Calculation for Aortic Valve Area
1060 Input "Heart Rate";R
1070 Input "Cardiac Output";CO
1080 Input "Aortic ms";APS
1090 Input "LVms";VPL
1100 Input "SEP sec/beat";SEP
1110 C=1;CO=CO*1000
1120 AVA=CO/(SEP*R*C*44.5*SQR (VPL-APS))
1130 CLS
1140 Print "Do you want a"
1150 Print "hardcopy printout"
1160 Input "yes=1, no=2";Z:CLS
1170 IF Z=2 then 2340
1180 CLS
1190 Goto 930
1195 REM Calculation for Mital Valve Area
1200 Input "Heart Rate";R
1210 Input "Cardiac Output";CO
1220 Input "DFP sec/beat";DFP
1230 Input "LAm or PCMP";LA
1240 Input LVdm;LV
1250 CO=CO x 1000
1260 DFP=DFP*P
1270 MVA=(CO/DFP)/(.85*44.3* SQR ((LA-LV)))
1280 CLS
1290 Print "Do you want a"
1300 Print "hardcopy printout"
1310 Input "yes=1, no=2";Z:CLS
1320 If Z=2 then 2370
1330 CLS
1340 Goto 960
1345 REM Calculation for O2 consumption
1350 Input "Cardiac Output";CO
1360 CI=CO/S
1370 Input "PO2";PA
1380 PA=PA*.01
1390 Input "PVO2";PV
1400 PV=PV*.01
1410 WX=HC*SA + (PA* .0031)
1420 XW=HC* SV + (PV* .0031)
1430 RW=X-W
1440 OC=CI RW*10
1450 OC=OC*S
1460 Goto 390
1465 REM Calculations for O2 content where the added dissolved oxygen
  is determined by percent O2 saturation
1470 MV=((2*SC)+IC)/3
1480 HC=HB*1.34
1490 If SA<.85 then 1580
1500 If SA>.85 <.95 then 1600
1510 If SA>.95 then 1620
1520 If SV<.85 then 1640
1530 If SV>.85 <.95 then 1660
1540 If SV>.95 then 1680
1550 If MV<.85 then 1700
1560 If MV>.85 <.95 then 1720
1570 If MV>.95 then 1740
1580 AC=SA*HC + .1
1590 Goto 1520
1600 AC=SA*HC + .2
1610 Goto 1520
1620 AC=SA*HC + .3
1630 Goto 1520
1640 PC=SV*HC + .1
1650 Goto 1550
1660 PC=SV*HC + .2
1670 Goto 1550
1680 PC=SV*HC + .3
1690 Goto 1550
1700 MV=MV*HC + .1
1710 Goto 1750
1720 MB=MV*HC + .2
1730 Goto 1750
1740 MB=MV*HC + .3
1750 Return
1755 REM Calculations for O2 content where the added dissolved oxygen
  is determined by oxygen delivery
1760 MV=((2*SC) + IC)/3
1770 HC=HB*1.34
1780 Input "O2X using";9:CLS
1790 Q=Q*.01
1800 If Q=.4 then 1830
1810 If Q=.6 then 1890
1820 If Q=1 then 1950
1830 AC=SA* HC+.7
1840 PC=SV* HC+.7
1850 MB=MV* HC+.7
1860 IV=IC* HC+.7
1870 VC=VS* HC+.7
1880 Goto 300
1890 AC=SA* HC+.1
1900 PC=SV* HC+.1
1910 MB=MV* HC+.1
1920 IV=IC* HC+.1
1930 VC=VS* HC+.1
1940 Goto 300
1950 AC=SA* HC+.7
1960 PC=SV* HC+.7
1970 MB=MV* HC+.7
1980 IV=IC* HC+.7
1990 VC=VS* HC +.1.7
2000 Goto 300
2010 CLS
2015 REM Output parameter print out to LCD screen
2020 Print "Body surface Area";Tab(8);:printusing "###.##";S;:print "M^2"
2025 REM loop statement for time delay for LCD screen display
2030 For L = 1 to 200:next L:CLS
2040 Print "Cardiac Output";TAB(5);:printusing
  "###.##";CO;:Print"l/min"
2050 For L = 1 to 200: next L:CLS
2060 Print "Cardiac Index";TAB(4);:printusing "###.##";CI;:print"
  l/min/m^2"
2070 For L = 1 to 200: next L:CLS
2080 Print "Stroke Volume";TAB(5);: printusing "###.##";V;:print"
  ml/beat"
2090 For L = 1 to 200: next L:CLS
2100 Print "Stroke volume Index";TAB(2);:printusing "###.##";F;:Print"
  ml/beat/M^2"
2110 For L = 1 to 200:next L:CLS
2120 Print "Pulmonary flow";TAB(5);:printusing "###.##";PF;:print"
  l/min"
2130 For L = 1 to 200:next L:CLS
2140 Print "Pulmonary flow index";TAB(4);:printusing "###.##";PI;:print"
  l/min/M^2"
2150 For L=1 to 200:Next L:CLS
2160 Print "QP/QS";Tab (9);:Print using "###.##";QPS
2170 For L=1 to 200:Next L:CLS
2180 Print "Systemic Resistance";Tab (4);:Print using
  "###.##";RS;:Print " units M^2"
2190 FOR L = 1 to 200:Next L:CLS
2200 Print "Total Pulm. Res."; TAB (4);: Print using "###.##"; RP;:Print"
  units M^2"
2210 For L=1 to 200:Next L:CLS
2220 Print "Pulm. Arteriolar Res."; Tab (4);:Print using
  "###.##";RA;:Print " units M^2"
2230 For L=1 to 200:Next L:CLS
2240 Print "Left-to-Right X"; Tab (8);: Print using "###.##";PLR;:Print
  "X"
2250 For L = 1 to 200:Next L:CLS
2260 Print "Left-to-Right Shunt"; Tab (4);:Print using
  "###.##";LR;:Print "l/min/m^2"
2270 For L = 1 to 200:Next L:CLS
2280 If SA >.94 then 2400
2290 Print "Right-to-Left X"; Tab (8);:Print using "###.##";PRL;:Print
  "X"
2300 For L = 1 to 200:Next L:CLS
2310 Print "Right-to-Left Shunt"; Tab (4);:Print using
  "###.##";RL;:Print "l/min/m^2"
2320 For L = 1 to 200:Next L:CLS
2330 Goto 2400
2340 Print "Aortic Valve Area"; Tab (8);: Print using
  "###.##";AVA;:Print " cm^2"
2350 For L = 1 to 200:Next L:CLS
2360 Goto 2460
2370 Print "Mitral Valve Area"; Tab (8);: Print using
  "###.##";MVA;:Print " cm^2"
2380 For L = 1 to 200:Next L:CLS
2390 Goto 2510
2400 CLS
2410 Print "Do you want"
2420 Print "to repeat"
2430 Input "Yes = 1, No = 2"; Z:CLS
2440 If Z = 1 Then 2010
2450 Goto 820
2460 Print "Do you want"
2470 Print "to repeat"
2480 Input "Yes = 1, No = 2"; Z:CLS
2490 If Z = 1 then 2340
2500 Goto 870
2510 Print "Do you want"
2520 Print "to repeat"
2530 Input "Yes = 1, No = 2"; Z:CLS
2540 If Z = 1 then 2370
2550 Goto 1030
2555 REM Calculations for O2 content where the added dissolved oxygen is
  determined by percent O2 sat.
2560 If IC<.85 then 2590
2570 If IC >.85 <.95 then 2610
2580 If IC >.95 then 2630
2590 IV = IC * HC + .1
2600 Goto 2650
2610 IV = IC * HC + .2
2620 Goto 2650
2630 IV = IC * HC + .3
2640 Goto 2650
2650 If VS < .85 then 2680
2660 If VS >.85 <.95 then 2700
2670 If VS > .95 then 2720
2680 VC = VS * HC + .1
2690 Goto 2730
2700 VC = VS * HC + .2
2710 Goto 2730
2720 VC = VS * HC + .3
2730 Return

```

Fig. 2. Computer program.

<u>INPUTS</u>	<u>PRINTOUT</u>
Name	NAME
Clinic number	Clinic No.
Age	Age
Birth date	Birth Date
Today's date	Today's Date
Height = 170 cm	Body Surface Area 1.81 M ²
Weight = 70 kg	Cardiac Output 4.20 l/min
Syst. art. sat. = 98	Cardiac Index 2.32 l/min/M ²
Pulm. art. sat. = 87	Stroke Volume 48.84 ml/beat
SVC sat. = 87	Stroke Volume Index 26.93 ml/beat/M ²
IVC sat. = 87	Pulmonary Flow 4.20 l/min
Pulm. vein sat. = 98	Pulmonary Flow Index 2.32 l/min/M ²
Hemoglobin = 12.5 g	QP/QS 1.00
Heart rate = 86 beats/min	Systemic Resistance 38.00 units M ²
Mean aortic blood pressure = 88	Total Pulm. Res. 38.00 units M ²
Mean PA pressure = 30	Pulm. Arteriolar Res. 3.89 units M ²
PCWP mean = 21	Left-to-Right % -0.0 %
Cardiac output = 4.2 L/min	Left-to-Right Shunt 0.00 l/min/M ²
Diastolic filling period = 0.39 sec/beat	Mitral Valve Area 0.83 cm ²
LV diastolic mean pressure = 5	

Fig. 3. Mitral stenosis (inputs and computer printout).

<u>INPUTS</u>	<u>PRINTOUT</u>
Name	NAME
Clinic number	Clinic No.
Age	Age
Birth date	Birth Date
Today's date	Today's Date
Height = 159 cm	Body Surface Area 1.55 M ²
Weight = 54 kg	Cardiac Output 4.30 l/min
Syst. art. sat. = 97	Cardiac Index 2.78 l/min/M ²
Pulm. art. sat. = 91	Stroke Volume 48.89 ml/beat
SVC sat. = 76	Stroke Volume Index 31.59 ml/beat/M ²
IVC sat. = 76	Pulmonary Flow 15.42 l/min
Pulm. vein sat. = 97	Pulmonary Flow Index 9.97 l/min/M ²
Hemoglobin = 14.6 g	QP/QS 3.59
Heart rate = 88 beats/ min	Systemic Resistance 26.98 units M ²
Mean art. pressure = 75	Total Pulm. Res. 7.52 units M ²
Mean PA pressure = 16	Pulm. Arteriolar Res. 0.80 units M ²
PCWP mean = 8	Left-to-Right % 71.4 %
Oxygen consumption = 117 mL/min/m ²	Left-to-Right Shunt 7.19 l/min/M ²

Fig. 4. Atrial septal defect (inputs and computer printout).

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