A simplified computer program for the performance of physiological calculations from cardiac catheterization data[1]

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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

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

$$\text{O}_2 \text{ consumption} = \text{CI} \times \text{A-V O}_2 \text{ difference} \times 10$$

$$\text{O}_2 \text{ capacity} = \text{hemoglobin} \times 1.34$$

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

$$\text{Cardiac output (systemic flow or } Q_s) = \frac{\text{O}_2 \text{ consumption in mL/min}}{(\text{systemic artery content} - \text{mixed venous content}) \times 10}$$

$$\text{O}_2 \text{ content} = (\% \text{ saturation} \times \text{O}_2 \text{ capacity}) + \text{dissolved oxygen}^*$$

$$\text{Pulmonary flow } (Q_p) = \frac{\text{O}_2 \text{ consumption in mL/min}}{(\text{pulmonary vein content})^\dagger - (\text{pulmonary artery content}) \times 10}$$

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

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

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

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

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

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

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

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

$$\text{Left-to-right shunt in L/min} = \left(\frac{\text{O}_2 \text{ consumption}}{[\text{arterial O}_2 \text{ content} - \text{pulmonary artery O}_2 \text{ content}] \times 10}\right) - \left(\frac{\text{O}_2 \text{ consumption}}{[\text{arterial O}_2 \text{ content} - \text{RV O}_2 \text{ content}] \times 10}\right)$$

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

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

* 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 02 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
345       REM Calculation of cardiac output
350       Input "O2 consumption";OC
360       OC = OC*S
370       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"
          l/min"
680       Lprint "Cardiac Index";TAB(8);:Lprintusing "##.##";CI;:L print"
          l/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"
          l/min"
720       Lprint "Pulmonary Flow Index";Tab(8);:Lprintusing
          "##.##";PI;:Lprint" l/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);1: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" l/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" l/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: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 PCWP";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    RR=WX-XW
1440    OC=CI RR*10
1450    OC=OC*S
1460    Goto 390
1465    REM Calculations for O2 content where the added dissovled 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 "O2% 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+1.7
1960    PC=SV* HC+1.7
1970    MB=MV* HC+1.7
1980    IV=IC* HC+1.7
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 %"; Tab (8);: Print using "###.#";PLR;:Print
        "%"
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 %"; Tab (8);:Print using "###.#";PRL;:Print
        "%"
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 Calcutions for O2 content were 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.

INPUTS

Name

Clinic number

Age

Birth date

Today's date

Height = 170 cm

Weight = 70 kg

Syst. art. sat. = 98

Pulm. art. sat. = 87

SVC sat. = 87

IVC sat. = 87

Pulm. vein sat. = 98

Hemoglobin = 12.5 g

Heart rate = 86 beats/min

Mean aortic blood pressure = 88

Mean PA pressure = 30

PCWP mean = 21

Cardiac output = 4.2 L/min

Diastolic filling period = 0.39 sec/beat

LV diastolic mean pressure = 5

PRINTOUT

```
NAME
Clinic No.
Age
Birth Date
Today's Date
Body Surface Area
          1.81 M^2
Cardiac Output
          4.20 l/min
Cardiac Index
          2.32 l/min/M^2
Stroke Volume
         48.84 ml/beat
Stroke Volume Index
     26.93 ml/beat/M^2
Pulmonary Flow
          4.20 l/min
Pulmonary Flow Index
          2.32 l/min/M^2
QP/QS      1.00
Systemic Resistance
         38.00 units M^2
Total Pulm. Res.
         38.00 units M^2
Pulm. Arteriolar Res.
          3.89 units M^2
Left-to-Right %
          -0.0 %
Left-to-Right Shunt
          0.00 l/min/M^2
Mitral Value Area
          0.83 cm^2
```

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

INPUTS

Name

Clinic number

Age

Birth date

Today's date

Height = 159 cm

Weight = 54 kg

Syst. art. sat. = 97

Pulm. art. sat. = 91

SVC sat. = 76

IVC sat. = 76

Pulm. vein sat. = 97

Hemoglobin = 14.6 g

Heart rate = 88 beats/ min

Mean art. pressure = 75

Mean PA pressure = 16

PCWP mean = 8

Oxygen consumption = 117 mL/min/m^2

PRINTOUT

```
NAME
Clinic No.
Age
Birth Date
Today's Date
Body Surface Area
          1.55 M^2
Cardiac Output
           4.30 l/min
Cardiac Index
          2.78 l/min/M^2
Stroke Volume
          48.89 ml/beat
Stroke Volume Index
     31.59 ml/beat/M^2
Pulmonary Flow
          15.42 l/min
Pulmonary Flow Index
          9.97 l/min/M^2
QP/QS      3.59
Systemic Resistance
          26.98 units M^2
Total Pulm. Res.
           7.52 units M^2
Pulm. Arteriolar Res.
           0.80 units M^2
Left-to-Right %
          71.4 %
Left-to-Right Shunt
          7.19 l/min/M^2
```

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

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