PPG FEATURES AND ITS APPLICATIONS
(Photoplethysmogram)

BS Bạch Tuyết --ECG

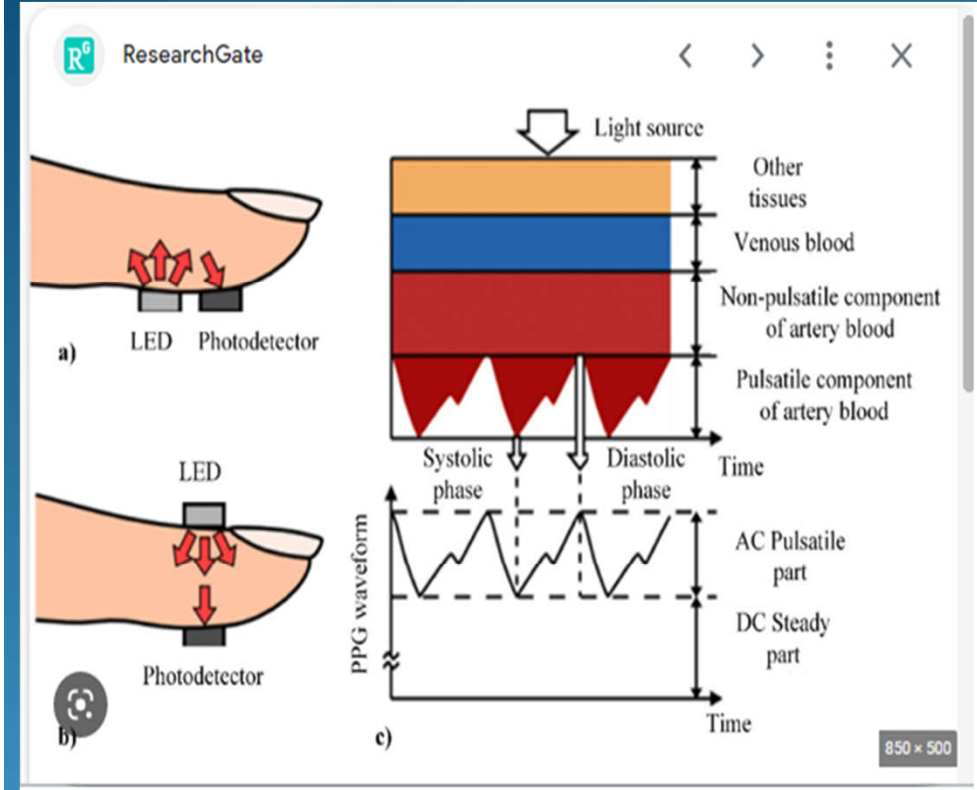
1. Khái niệm về PPG
2. Hình ảnh 1 PPG điển hình
3. Ứng dung trong :

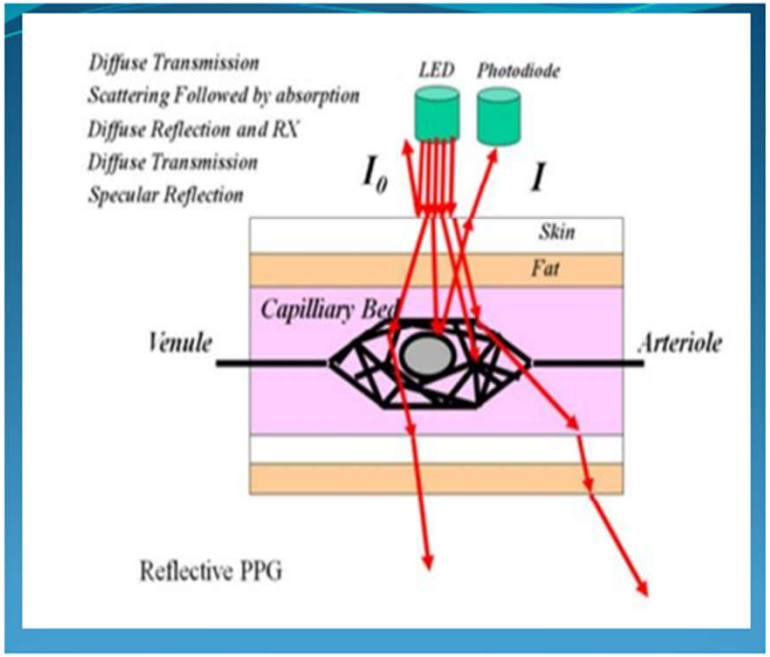
**** Monitoring heart rate**

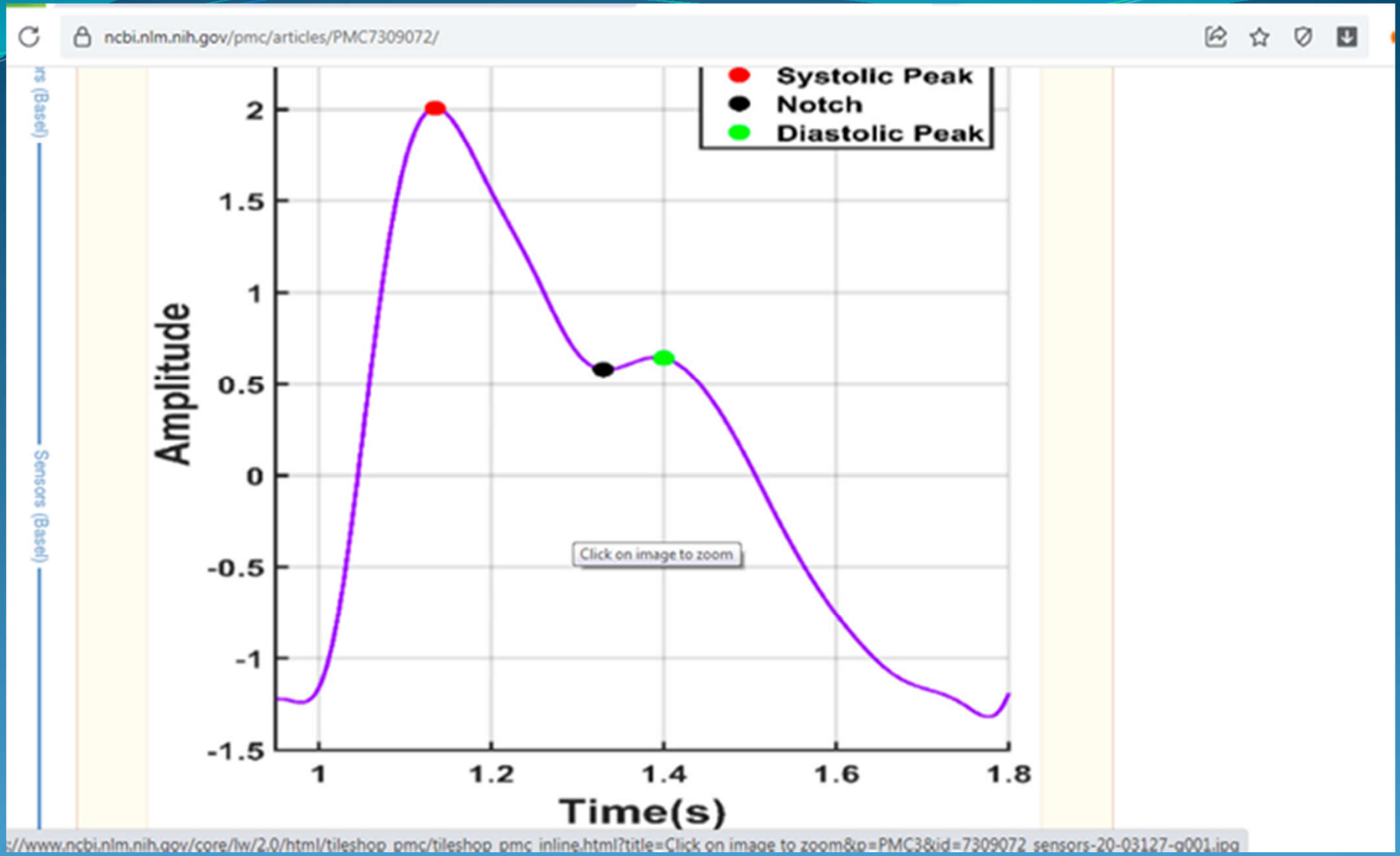
**** Monitoring blood pressure**

**** Monitoring depth of anesthesia**

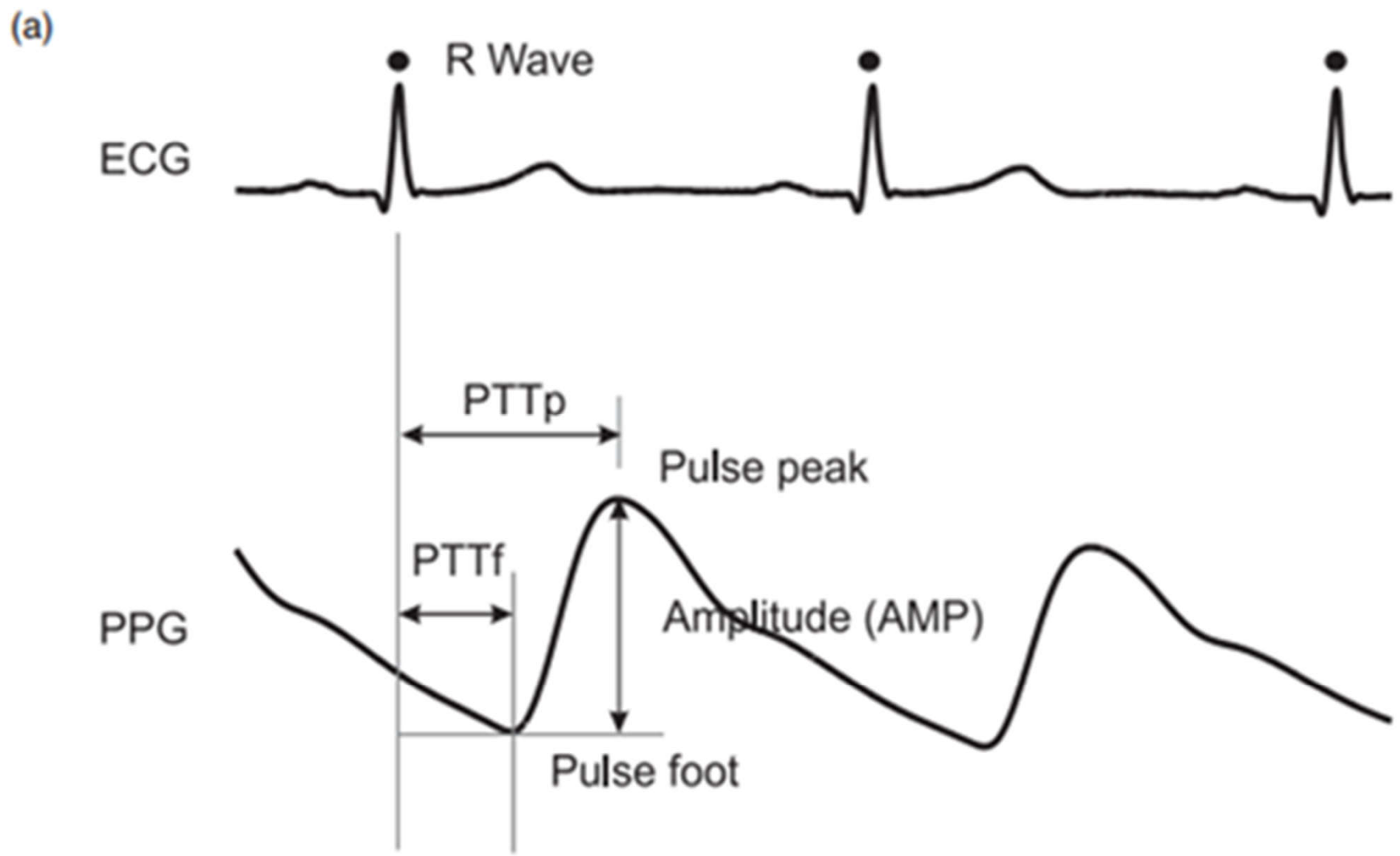
**** can detect diabetes**

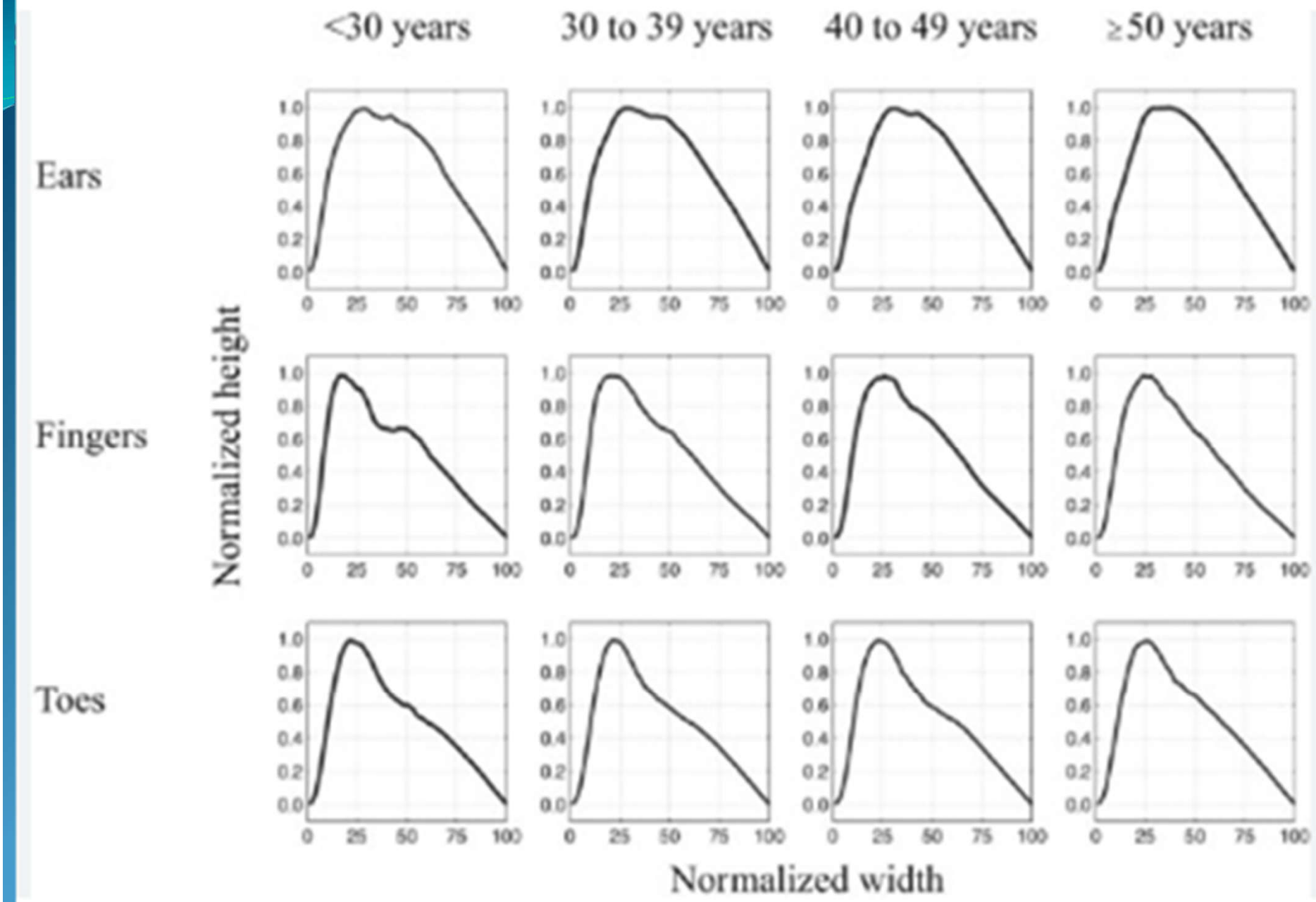

ResearchGate
Light source
Other tissues
Venous blood
Non-pulsatile component of artery blood
Pulsatile component of artery blood
LED
Photodetector
a)
Systolic phase
Diastolic phase
Time
LED
Photodetector
b)
PPG waveform
AC Pulsatile part
DC Steady part
Time
c)
850 × 500

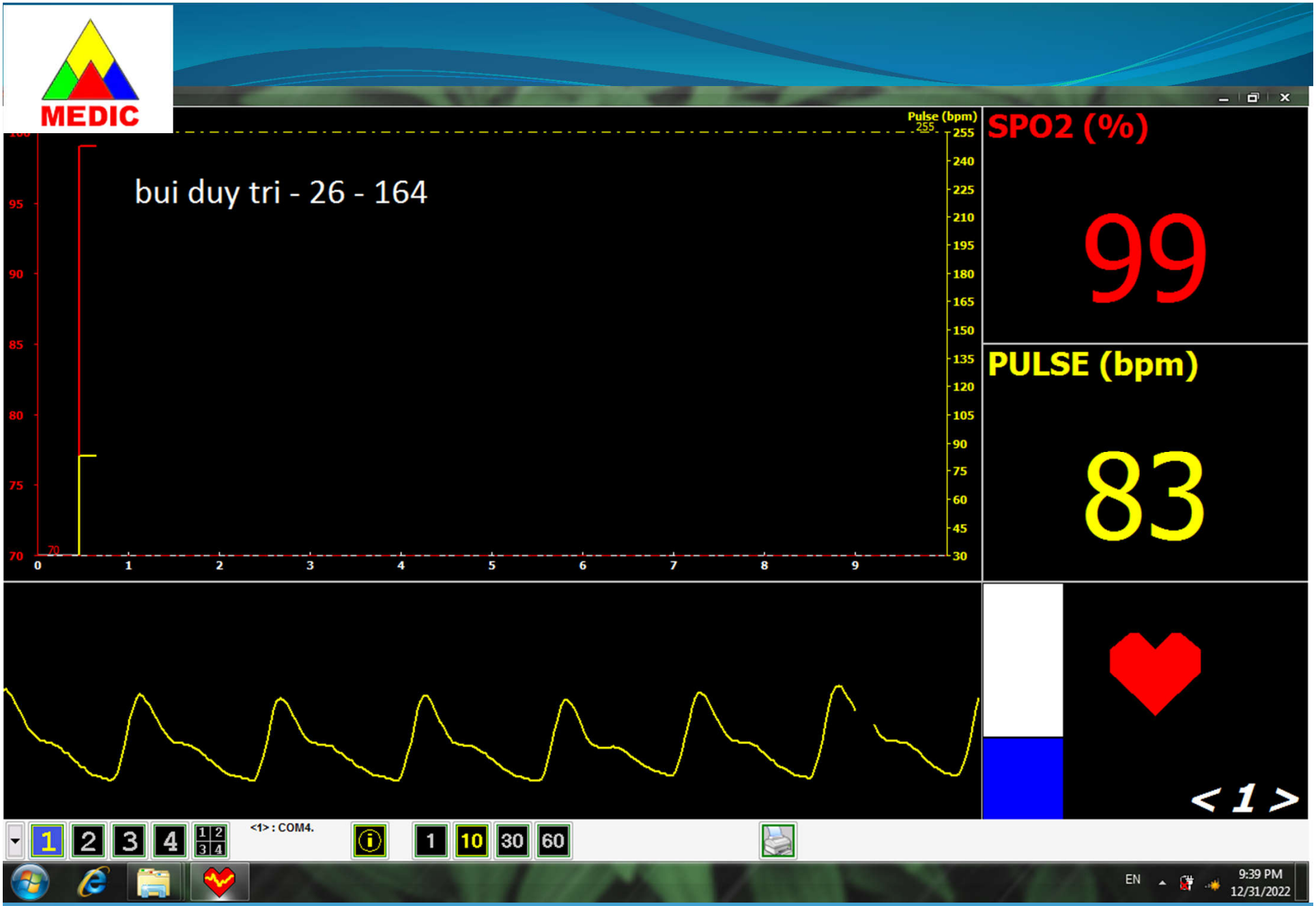

Diffuse Transmission
Scattering Followed by absorption
Diffuse Reflection and RX
Diffuse Transmission
Specular Reflection
LED
Photodiode
I_0
I
Skin
Fat
Capilliary Bed
Venule
Arteriole
Reflective PPG

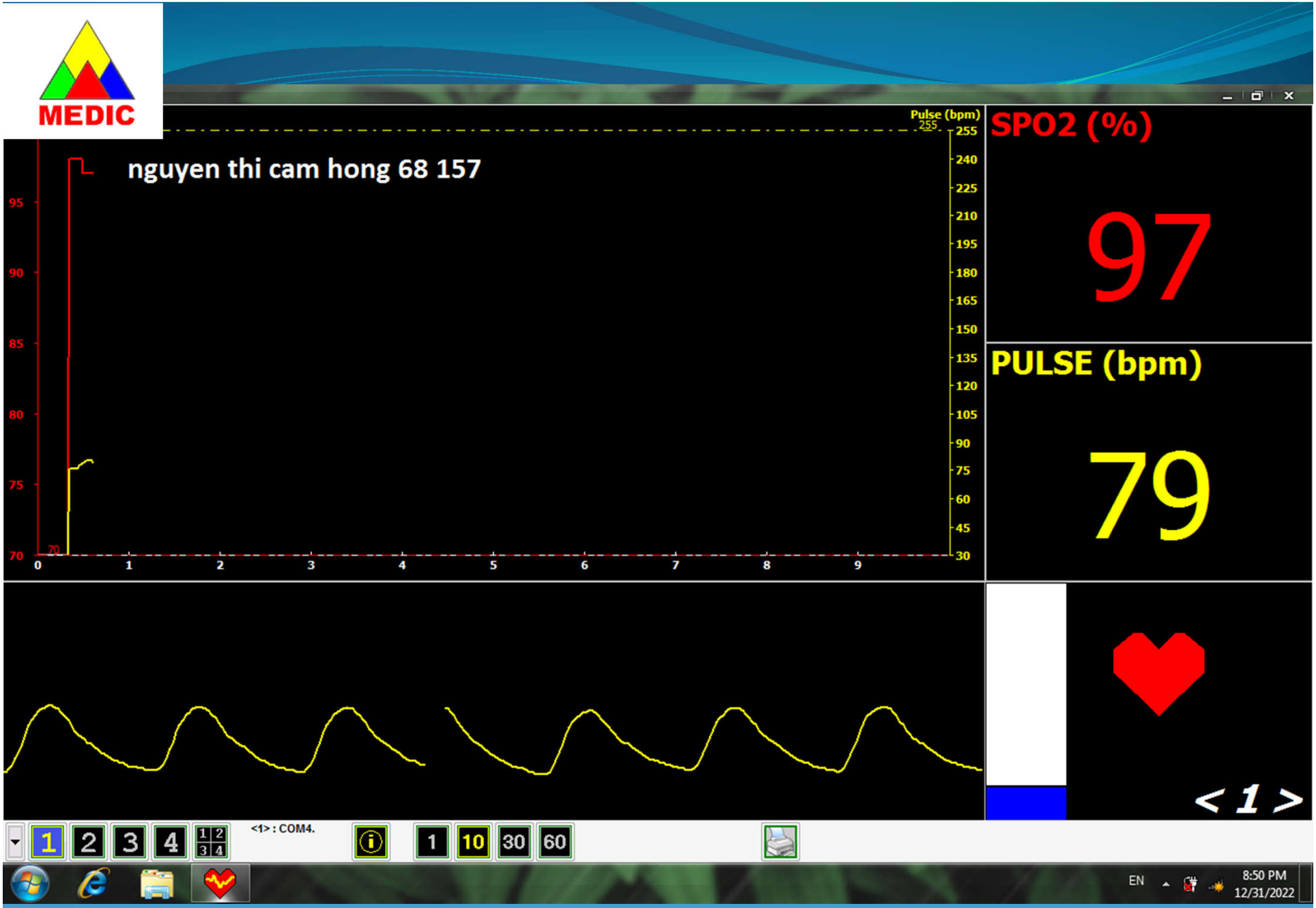

ncbi.nlm.nih.gov/pmc/articles/PMC7309072/
Systolic Peak
Notch
Diastolic Peak
Amplitude
2
1.5
1
0.5
0
-0.5
-1
-1.5
1
1.2
1.4
1.6
1.8
Time(s)
Click on image to zoom
Sensors (Basel)
://www.ncbi.nlm.nih.gov/core/lw/2.0/html/tileshop_pmc/tileshop_pmc_inline.html?title=Click on image to zoom&p=PMC3&id=7309072_sensors-20-03127-g001.jpg


Camera
Flash
96
85

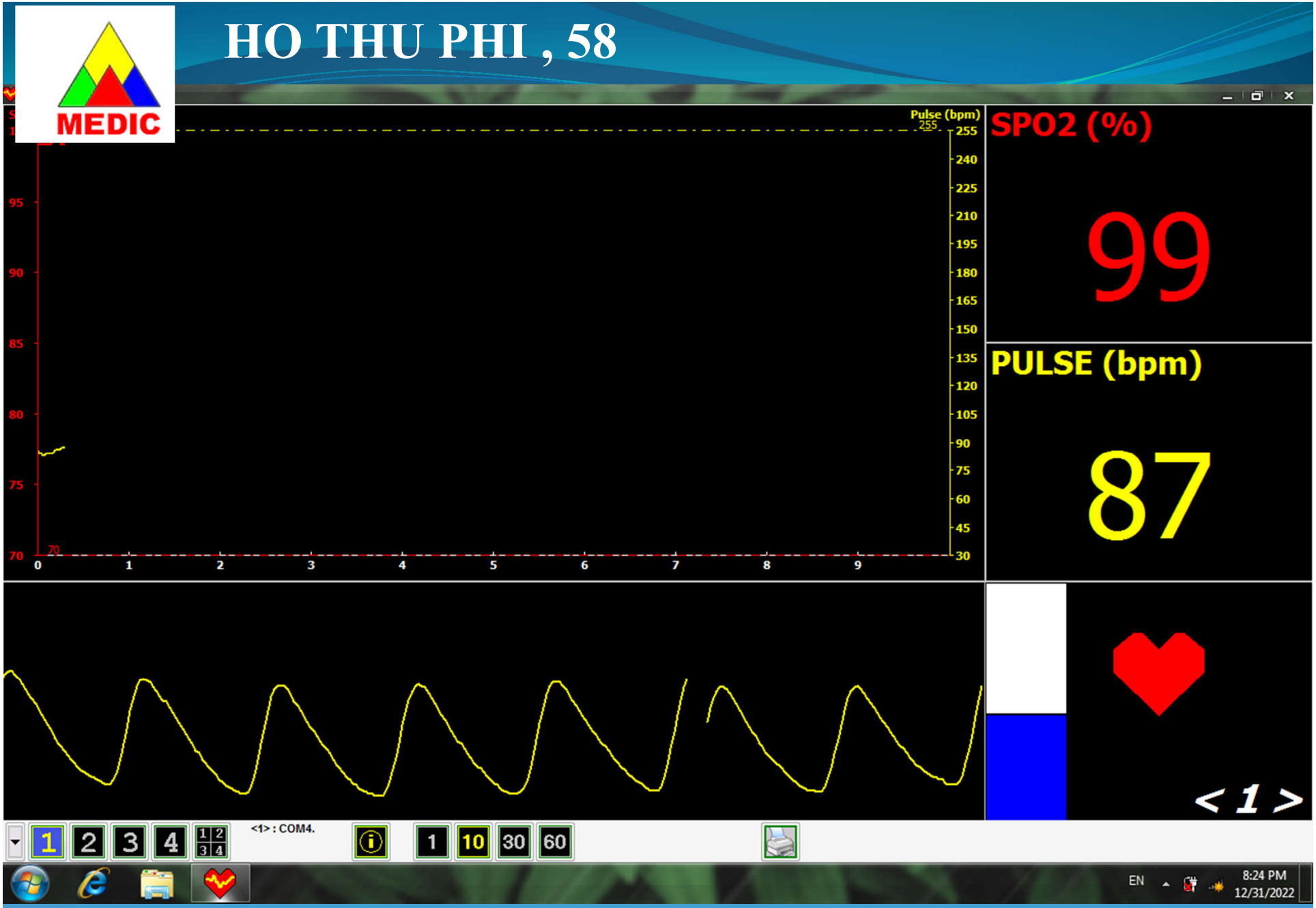

(a)
R Wave
ECG
PTTp
Pulse peak
PTTf
PPG
Amplitude (AMP)
Pulse foot


<30 years
30 to 39 years
40 to 49 years
≥50 years
Ears
Fingers
Toes
Normalized height
Normalized width
0.0
0.2
0.4
0.6
0.8
1.0
0
25
50
75
100


MEDIC
Pulse (bpm)
255
bui duy tri - 26 - 164
SPO2 (%)
99
PULSE (bpm)
83
< 1 >
<1> : COM4.
EN
9:39 PM
12/31/2022

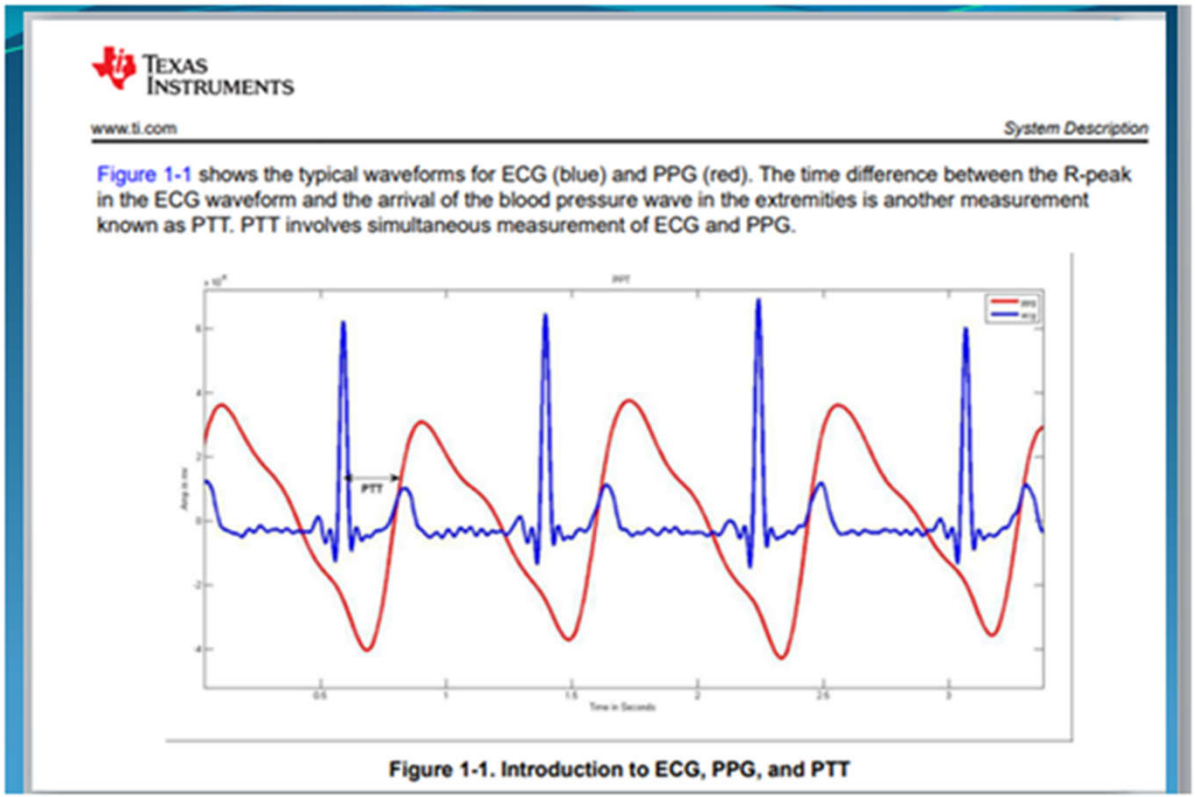

MEDIC
Pulse (bpm)
255
nguyen thi cam hong 68 157
SPO2 (%)
97
PULSE (bpm)
79
< 1 >
<1> : COM4.
EN
8:50 PM
12/31/2022

HO THU PHI , 58


MEDIC
Pulse (bpm)
255
SPO2 (%)
99
PULSE (bpm)
87
< 1 >
<1> : COM4.
1
2
3
4
1 2 3 4
1
10
30
60
EN
8:24 PM
12/31/2022

1. MONITORING HEART RATE

$$HR = \frac{60}{Peaks\ Interval\ (s)}$$



Texas Instruments

www.ti.com System Description

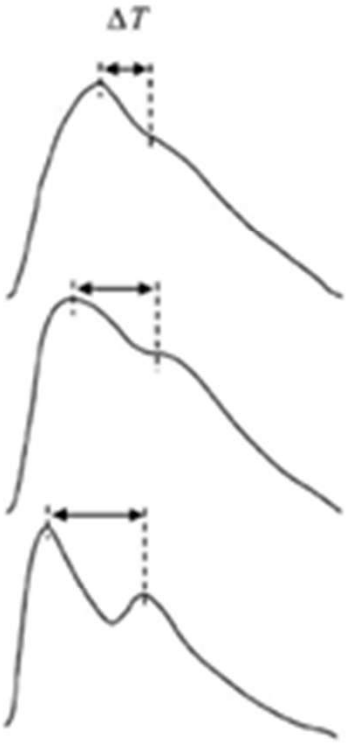
Figure 1-1 shows the typical waveforms for ECG (blue) and PPG (red). The time difference between the R-peak in the ECG waveform and the arrival of the blood pressure wave in the extremities is another measurement known as PTT. PTT involves simultaneous measurement of ECG and PPG.

Figure 1-1. Introduction to ECG, PPG, and PTT

Tuổi mạch máu : là 1 chỉ số mới về sức khỏe tim mạch. Chức năng và tuổi tác của mạch máu suy giảm 1 cách tự nhiên theo tuổi tác. Quá trình này gọi là sự lão hóa mạch máu , bao gồm sự tăng độ cứng và đường kính động mạch lớn. Cuối cùng , nó có thể dẫn đến tổn thương tim ,thận , não. Một trong những chỉ số lão hóa mạch máu là độ cứng đm 2. Pulse wave velocity (PWV). Khi mạch máu cứng hơn hay co lại nhiều hơn, máu di chuyển nhanh hơn và tạo nhiều áp lực hơn. PTT ngắn hơn, sẽ gây HA cao hơn.

Large Artery Stiffness Index:

$$SI = \frac{h}{\Delta T}$$



Age : 60 *yrs*

ΔT = 147 *ms*

SI = 12.2 *m* / *s*

Age : 45 *yrs*

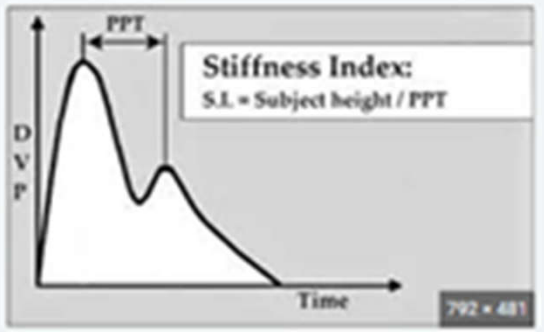
ΔT = 270 *ms*

SI = 6.8 *m* / *s*

Age : 29 *yrs*

ΔT = 1346 *ms*

SI = 5.4 *m* / *s*

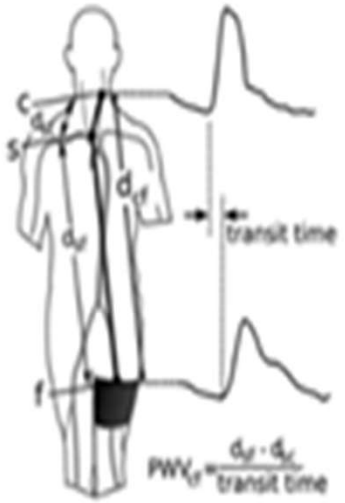


Pulse Wave Velocity is a risk predictor for:

- Hypertension
- Diabetes
- Stroke
- Renal Disease
- Pulmonary
- Inflammatory
- Cardiovascular

$$PWV = \frac{L}{PTT} = \sqrt{\frac{E.h}{2r\rho}}$$

$$E = E_0 e^{\alpha p}$$



Right carotid-femoral path length (mm)

= 100.36
- (0.70 × Age[years])
+ (137.81 × Height[m])
+ (0.51 × Weight[kg])
- (0.18 × heart rate [bpm])
+ (46.25 [if male], 53.89 [male])

$$PWV_{cf} = \frac{d_{cf} - d_{ct}}{\text{transit time}} \quad (1)$$

$$PWV_d = 0.8\,\frac{d_{ct}}{\text{transit time}} \quad (2)$$

Pulse Wave Velocity using Moens-Korteweg equation Calculator

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Chemistry | Biochemistry

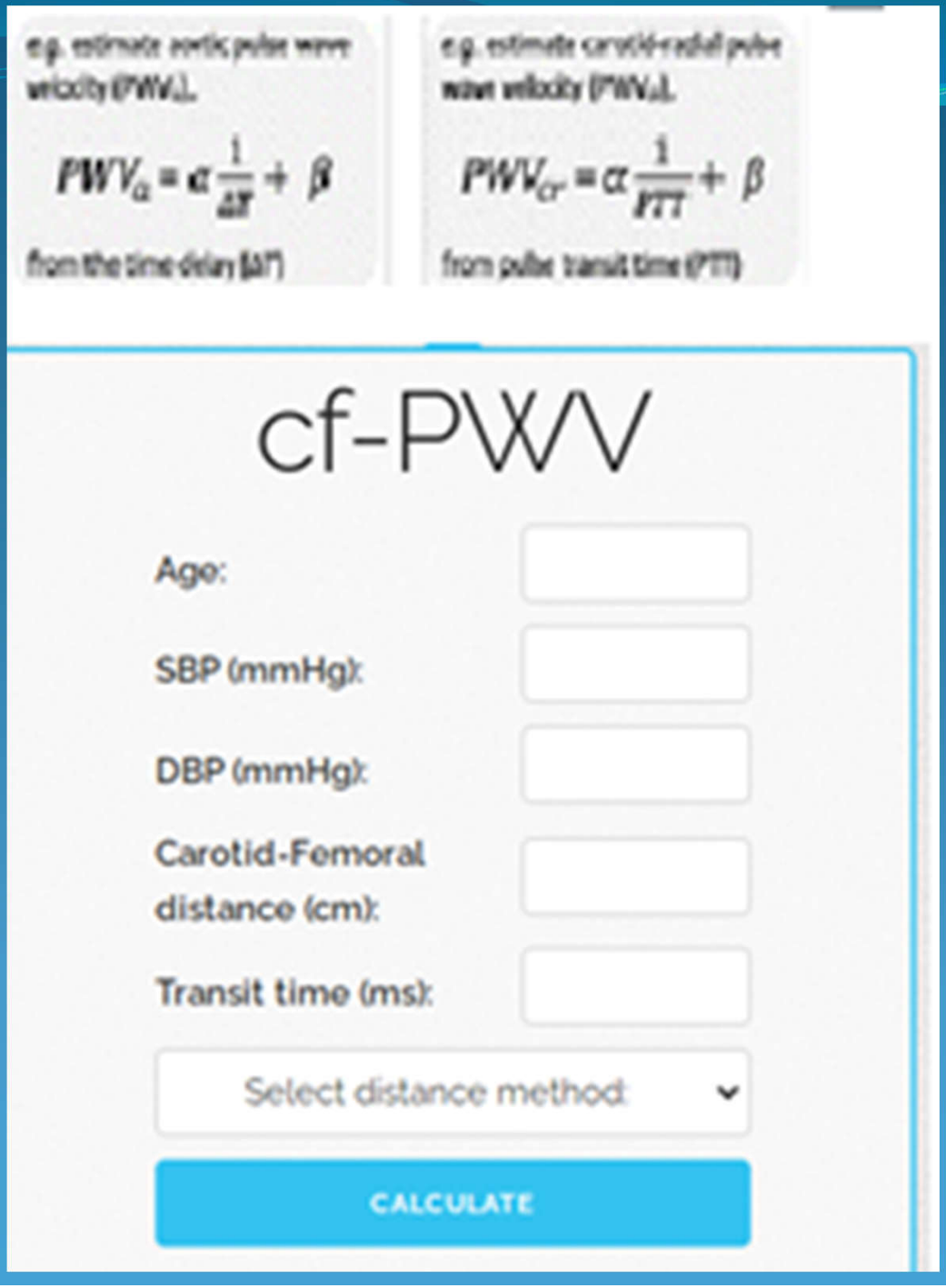
Biochemistry | Hemodynamics

sqrt((10.7*11.5)/(2*11*10.9))=0.716335

Elastic (tangent) Modulus at Blood Pressure P [E]	10,7 Pascal	+10% -10%
Thickness of Artery [h_0]	11,5 Meter	+10% -10%
Blood Density [ρ_{blood}]	11 Kilogram per Cubic	+10% -10%
Radius of Artery [R_0]	10,9	+10% -10%
Pulse Wave Velocity using Moens-Korteweg equation [PWV]	0.716335 Pascal	Copy

Calculate | Steps

Formula | Reset


e.g. estimate aortic pulse wave velocity (PWV$_{\alpha}$).
$PWV_{\alpha} = \alpha \frac{1}{\Delta T} + \beta$
from the time delay (ΔT)
e.g. estimate carotid-radial pulse wave velocity (PWV$_{cr}$).
$PWV_{cr} = \alpha \frac{1}{PTT} + \beta$
from pulse transit time (PTT)
cf-PWV
Age:
SBP (mmHg):
DBP (mmHg):
Carotid-Femoral distance (cm):
Transit time (ms):
Select distance method
CALCULATE

MONITORING BLOOD PRESSURE

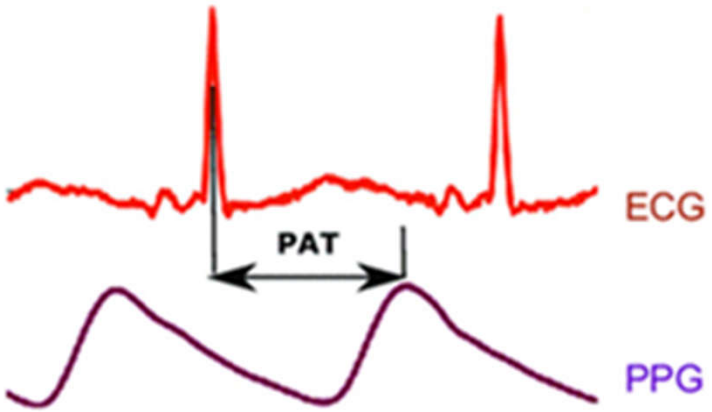
$$BP = -\frac{2}{\alpha} \cdot lnPTT + \frac{\ln\frac{2r\rho L^2}{hE_0}}{\alpha}$$

e.g. estimate systolic blood pressure (SBP)

$$SBP = \alpha \frac{1}{PAT} + \beta$$

from pulse arrival time (PAT)

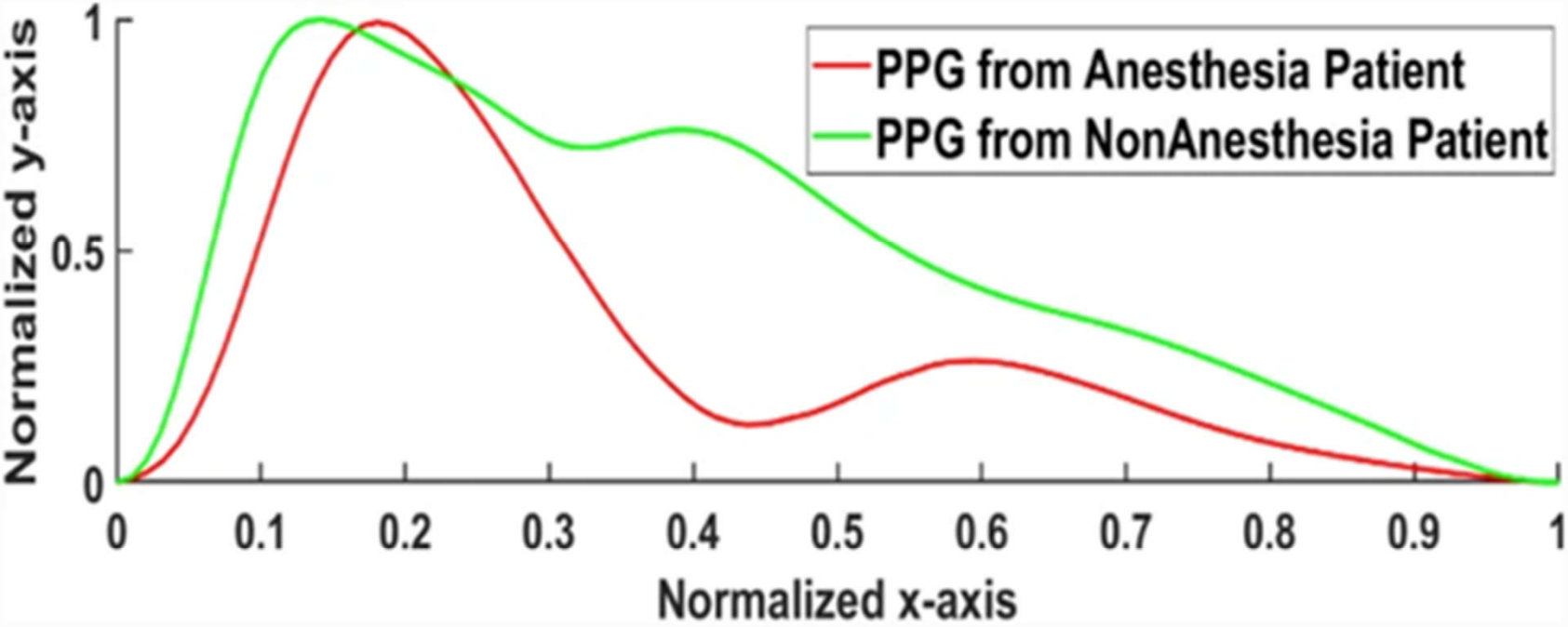
Pulse Arrival Time (PAT), which represents the delay from the heart pulse to the blood arriving to the fingertip



$$BP(t) = \gamma + \frac{\delta}{PAT(t)^2} \ln(\alpha \ln(\beta \cdot PPG(t))^2$$

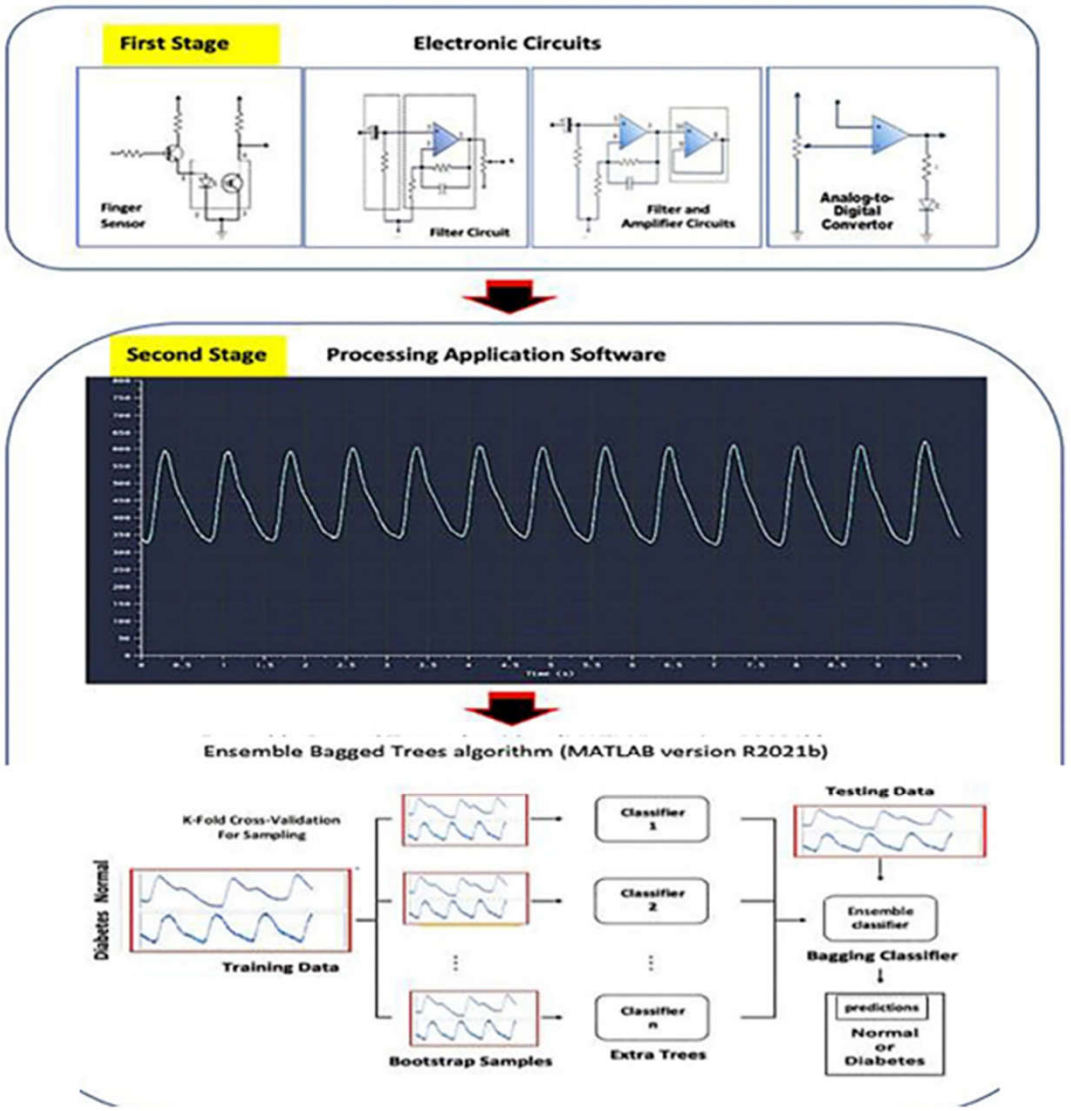
MONITORING DEPTH OF ANESTHENIA

Fig. 5



The average and normalized PPG waveform waveforms of anesthesia and non-anesthesia patients admitted to the hospital

PPG IN DETECTION DIABETES



Photoplethysmography signal can detect diabetes

KẾT LUẬN:

PPG là 1 kỹ thuật chi phí thấp , dễ sử dụng , giúp cho BS nhiều trong việc chẩn đoán .

Mặc dù được tìm ra vào năm 1930 , ngày nay nó được thiết kế với những dụng cụ nhỏ , gọn , và với sự trợ giúp của app,AI…

Bài báo cáo này giúp BS hiểu khái niệm về PPG để khi có phương tiện , chúng ta có thể hiểu hơn về nguyên lý hoạt động , giúp việc chẩn đoán bệnh tốt hơn.

THAM KHẢO :

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2. https://www.amperordirect.com/pc/help-pulse-oximeter/z-what-is-oximeter-plethysmograph.html
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