INTR2105
Interprétation de l'électrocardiogramme

III: ECG NORMAL et variantes

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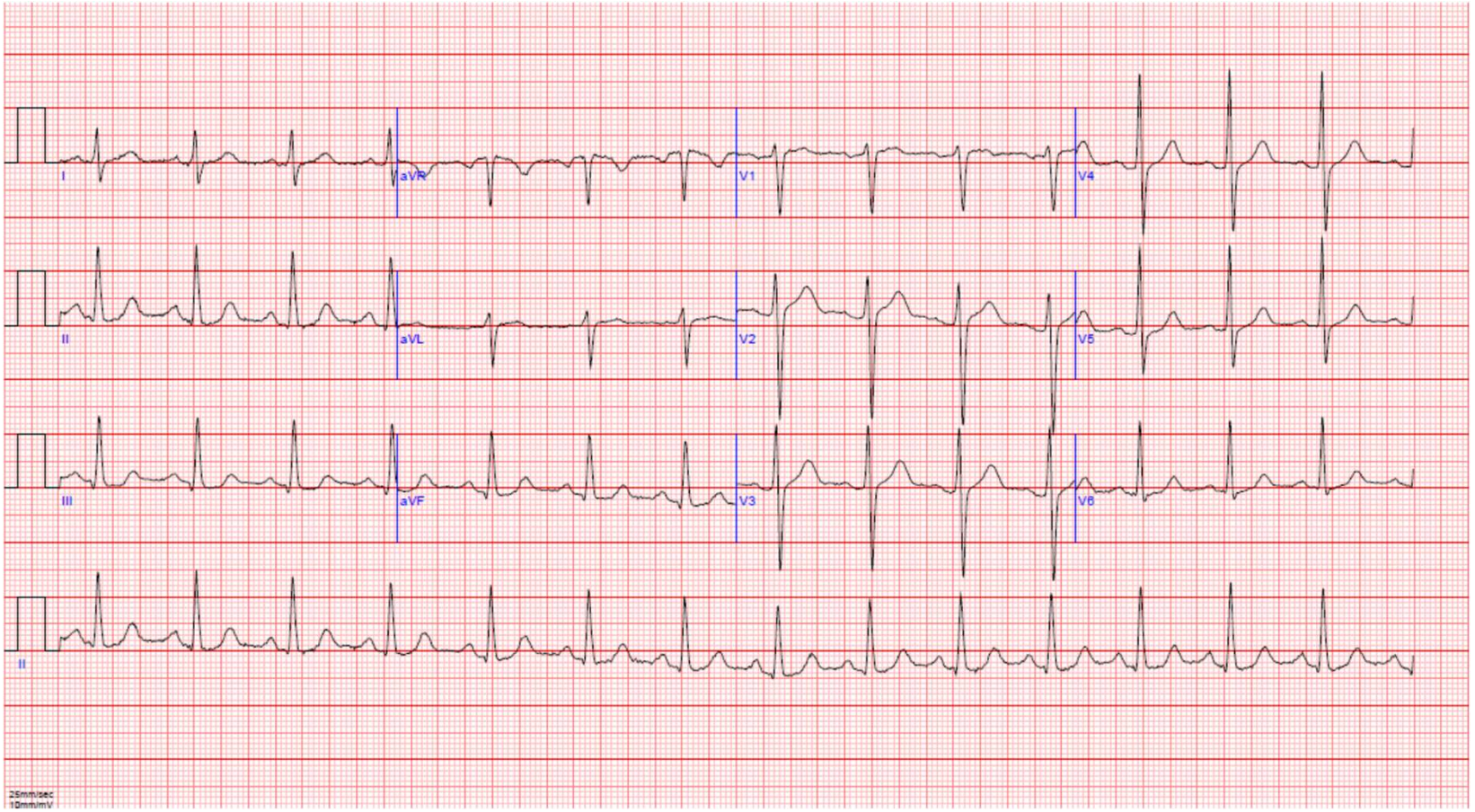
Cliniques Universitaires St.Luc

UCL, Bruxelles

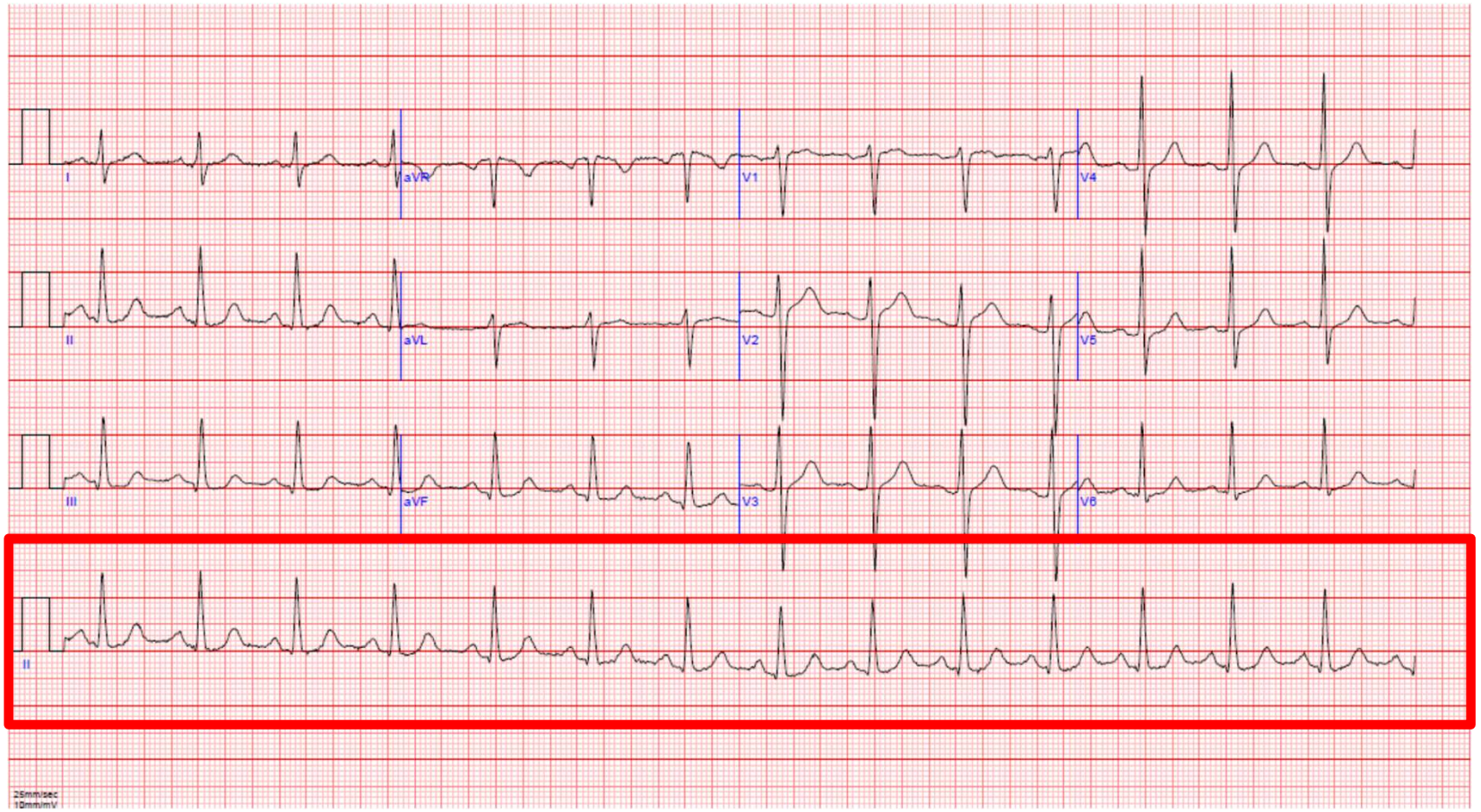
METHODE ANALYSE ECG

ECG homme 60 ans

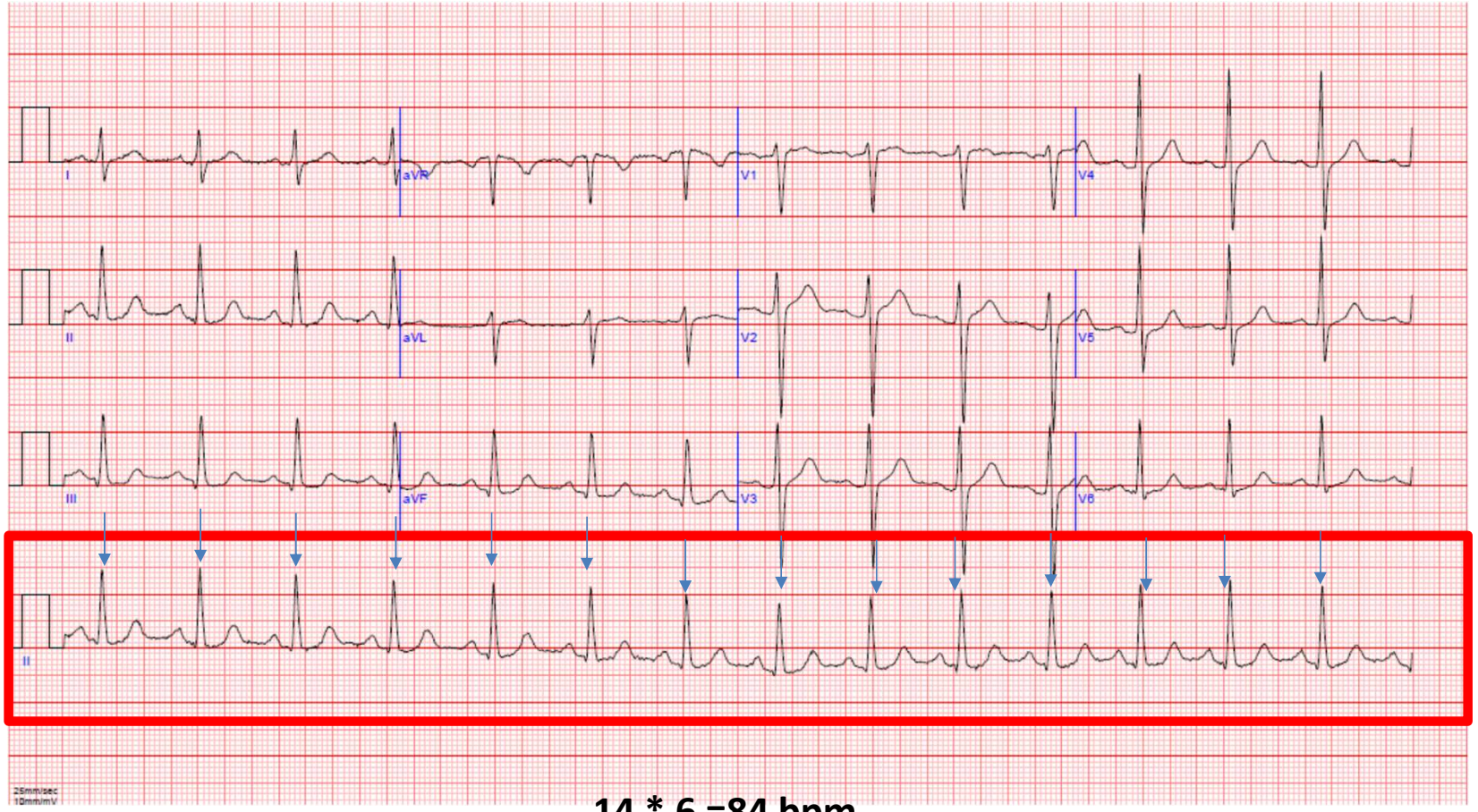


Résumé Analyse ECG

1. Rythme
   a) Fréquence
   b) Régularité
   c) Origine du rythme
2. Dépolarisation auriculaire (P)
3. Conduction auriculo-ventriculaire (PQ)
4. Dépolarisation ventriculaire (QRS)
   a) Durée
   b) Axe Frontal
   c) Morphologie
      a) Dérivations Périphériques
      b) Dérivation Précordiales
5. Repolarisation ventriculaire
   a) ST
   b) T
   c) QT
   d) U

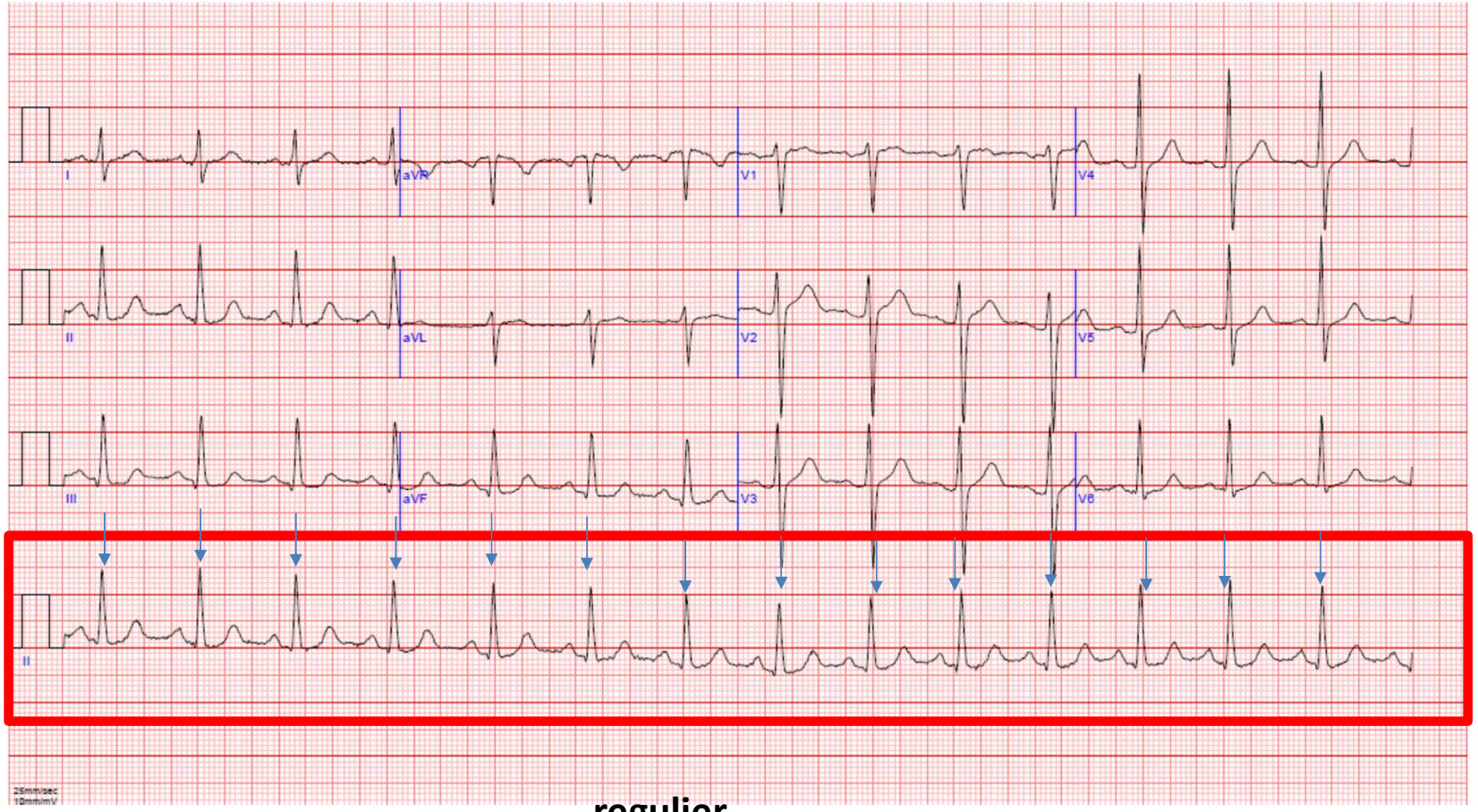

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
25mm/sec
10mm/mV

Fréquence



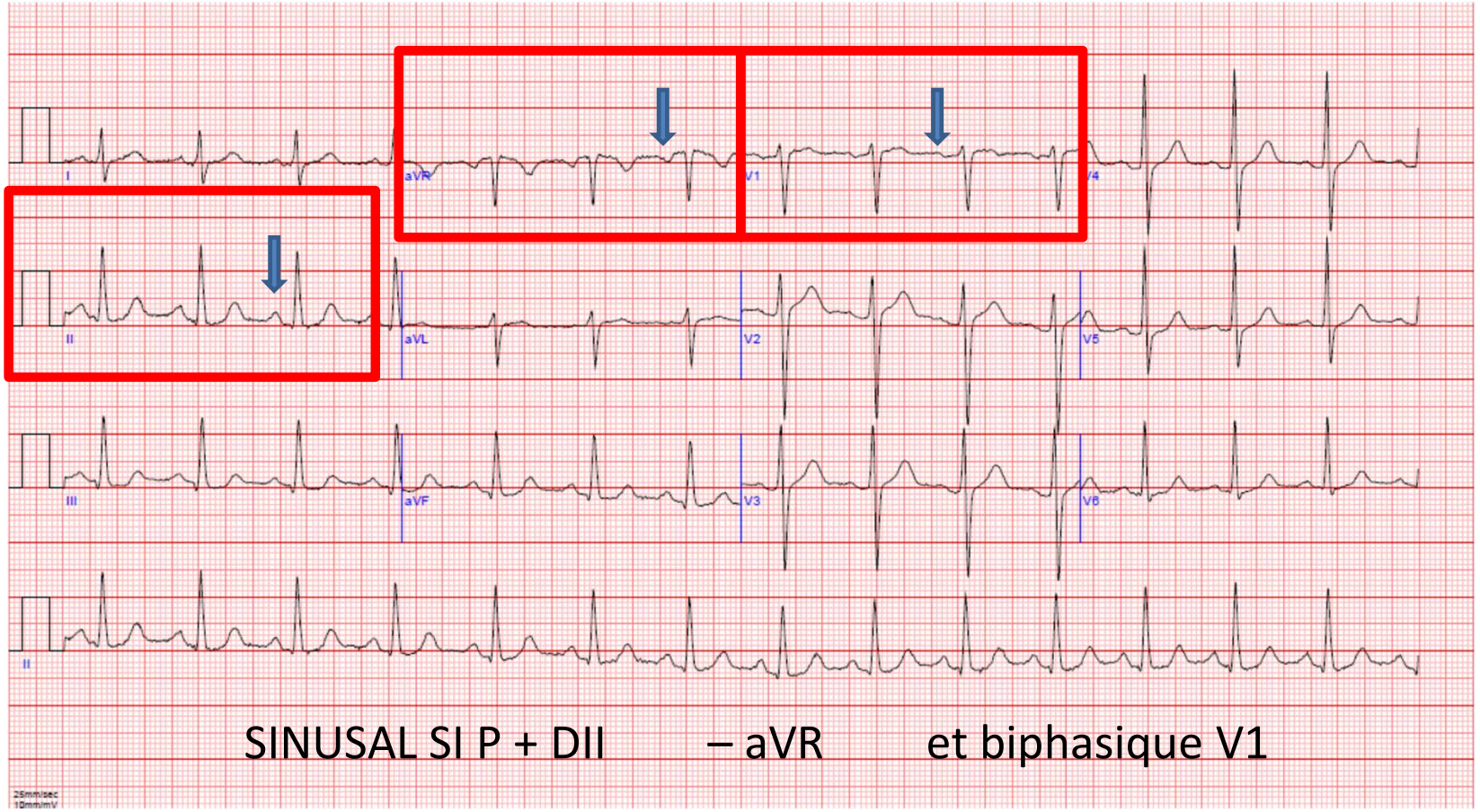
14 * 6 =84 bpm

Régularité



regulier

Origine du rythme



SINUSAL SI P + DII – aVR et biphasique V1

Résumé Analyse ECG

1. Rythme
   a) Fréquence **84 bpm**
   b) Régularité **régulier**
   c) Origine du rythme **sinusal**
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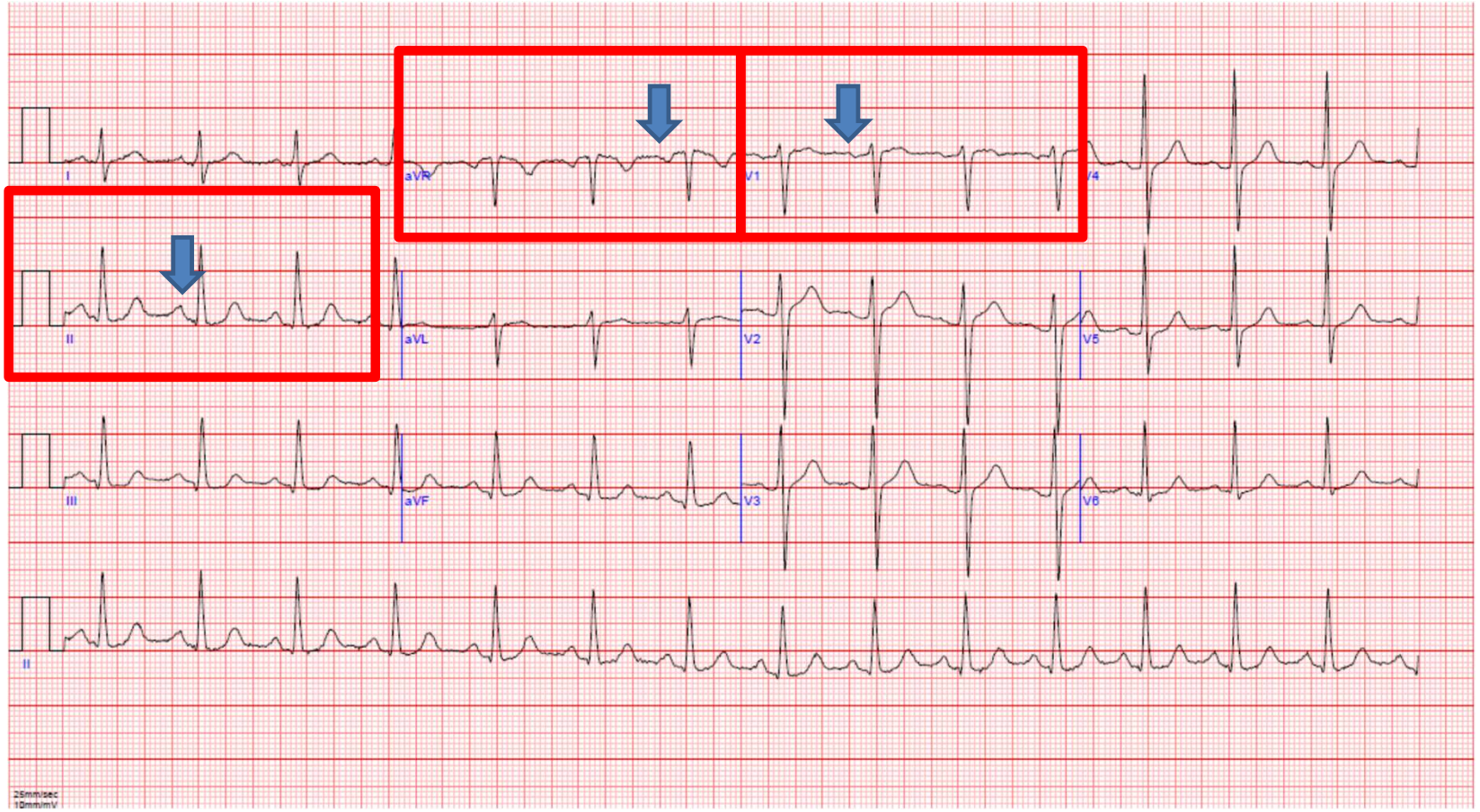
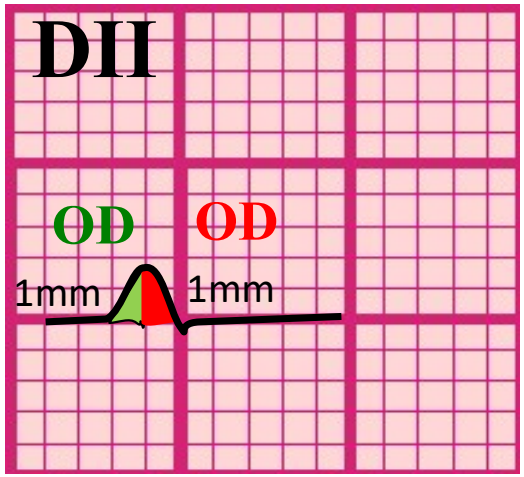
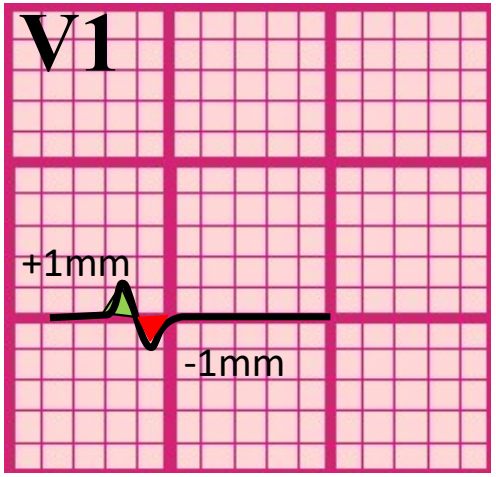
Ondes P



Critères de normalité onde P

Amplitude **2 mm**





Durée **<120 ms (3 pet. C.)**

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   a) Fréquence **84 bpm**
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2. Dépolarisation auriculaire (P): < 2 mmDII, < 120 ms
3. Conduction auriculo-ventriculaire (PQ)
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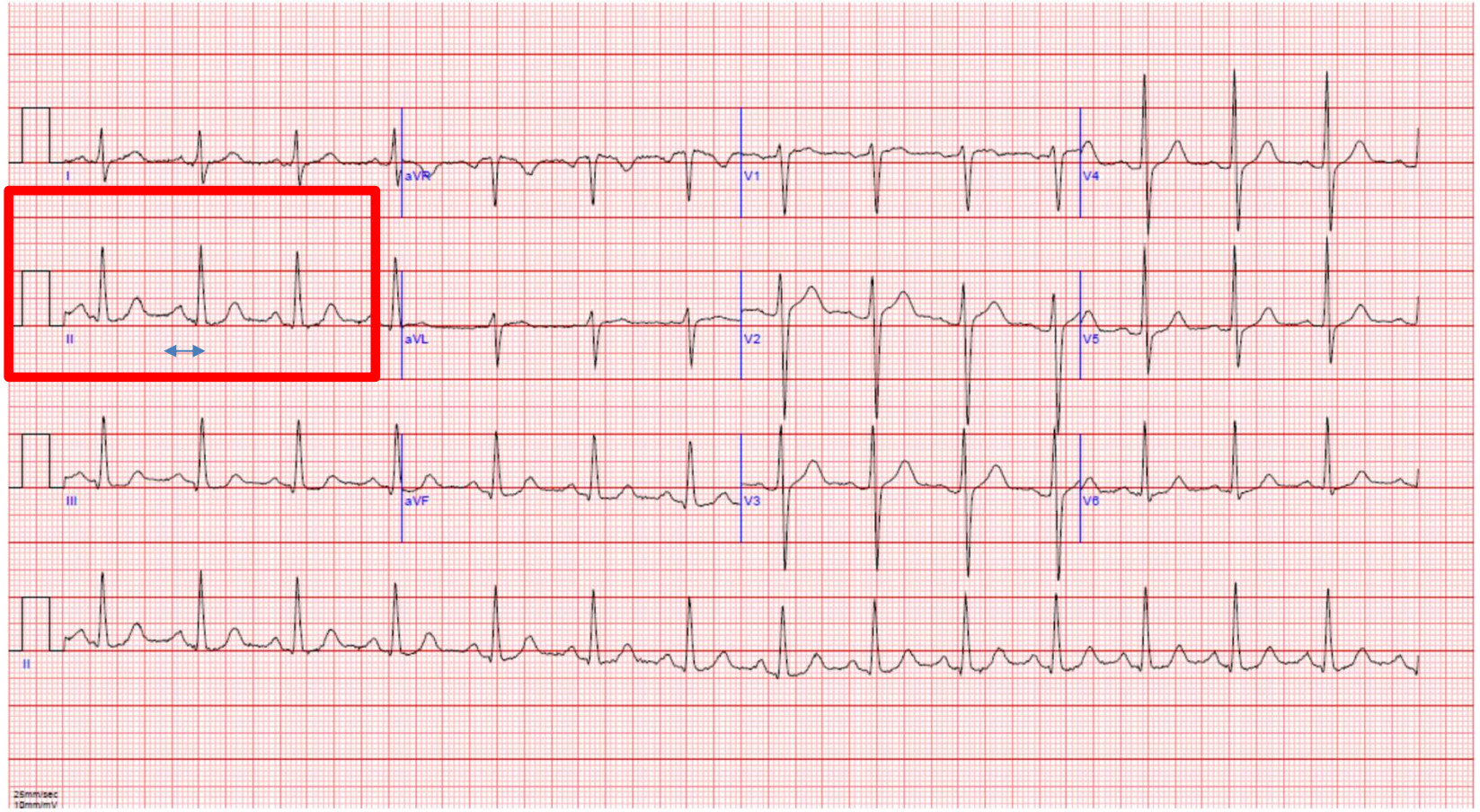
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
25mm/sec
10mm/mV

Segment PQ

Max 200 ms
5 pet carrées
1 gd carrée

Résumé Analyse ECG

1. Rythme
   a) Fréquence **84 bpm (60-100)**
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2. Dépolarisation auriculaire (P): < 2 mmDII, < 120 ms
3. Conduction auriculo-ventriculaire (PQ) <200 ms
4. Dépolarisation ventriculaire (QRS)
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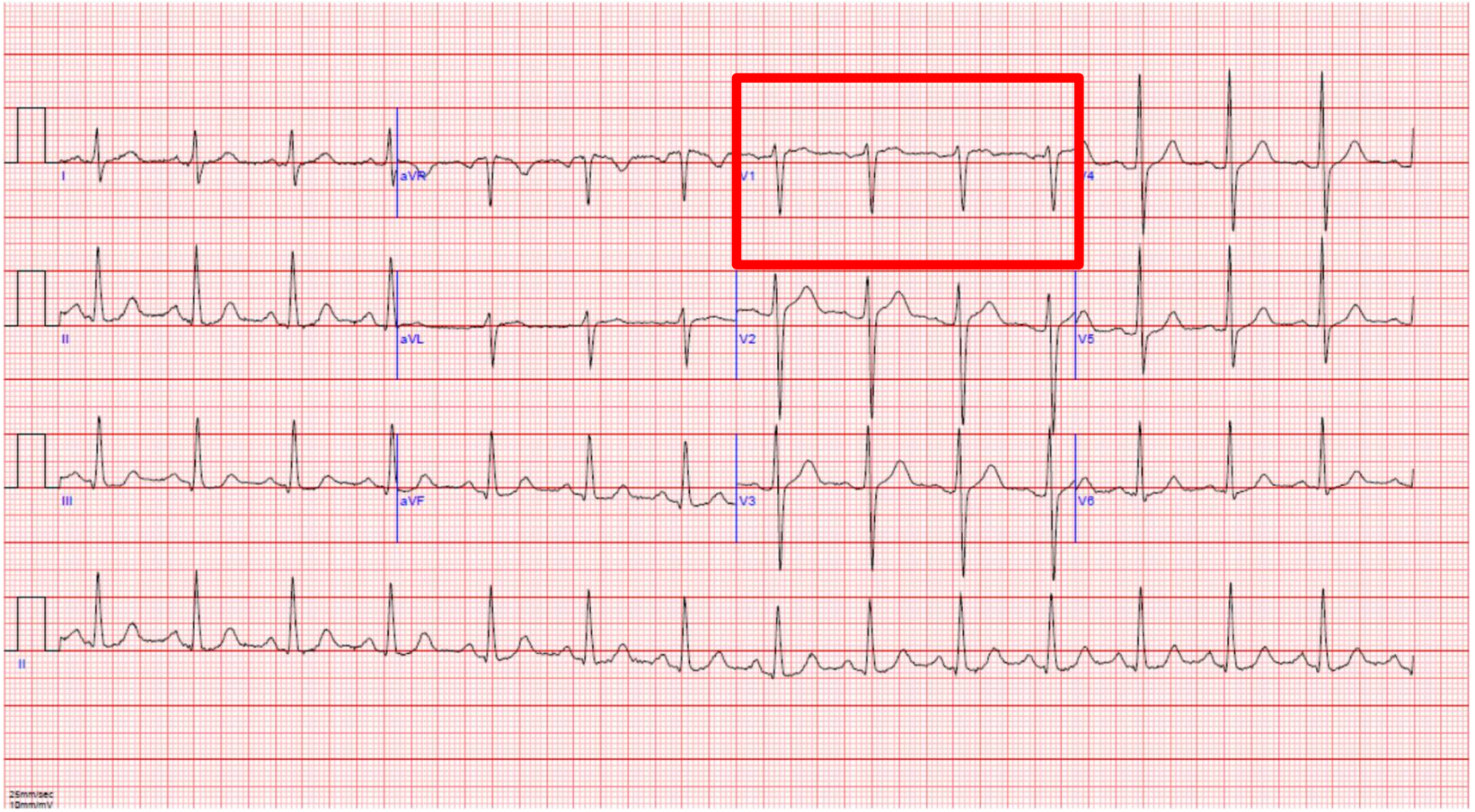
Durée QRS



Durée QRS

Nl<100 ms
Max 120 ms
3 pet carrées

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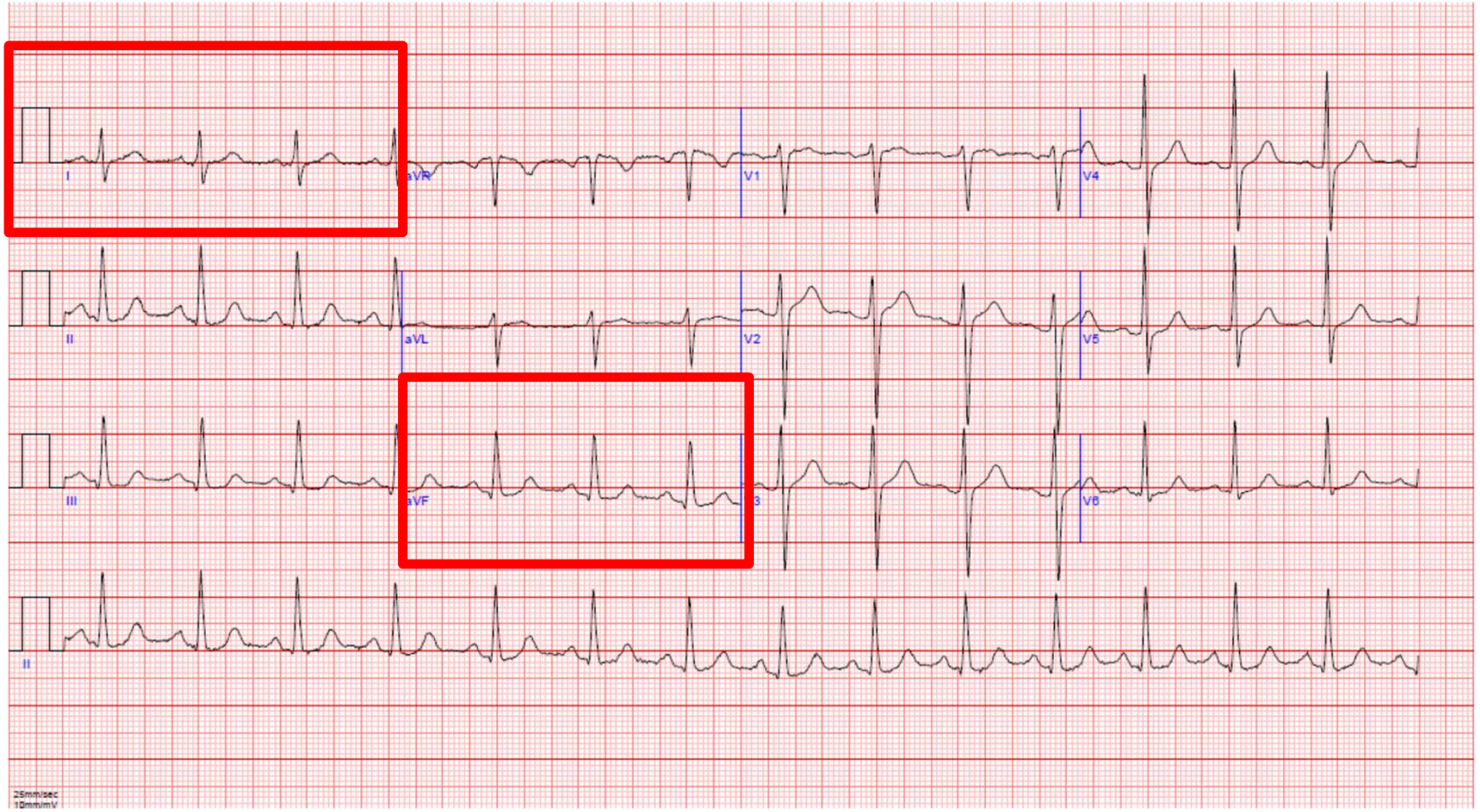
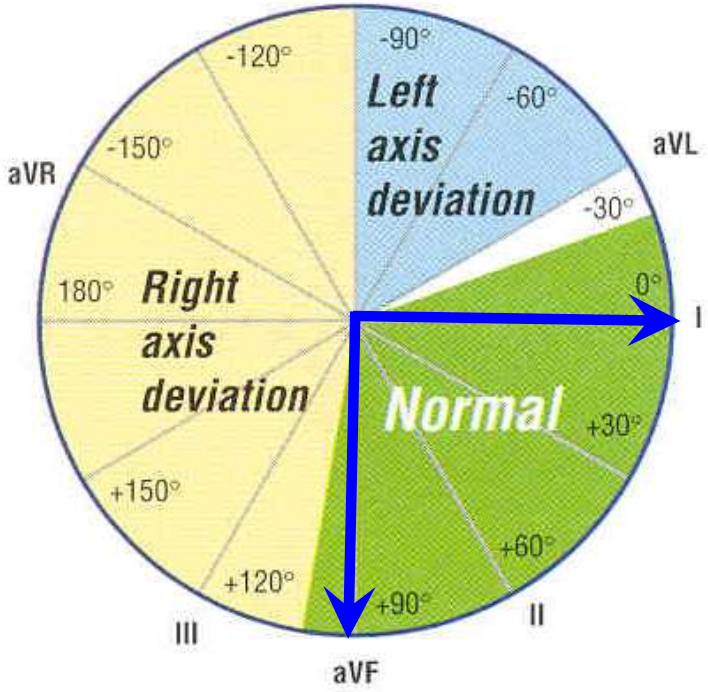
Axe QRS



Axe QRS:



Si le complexe moyen QRS est postitif en DI et VF: l'axe est Normal (entre 0 et 90 degrées)

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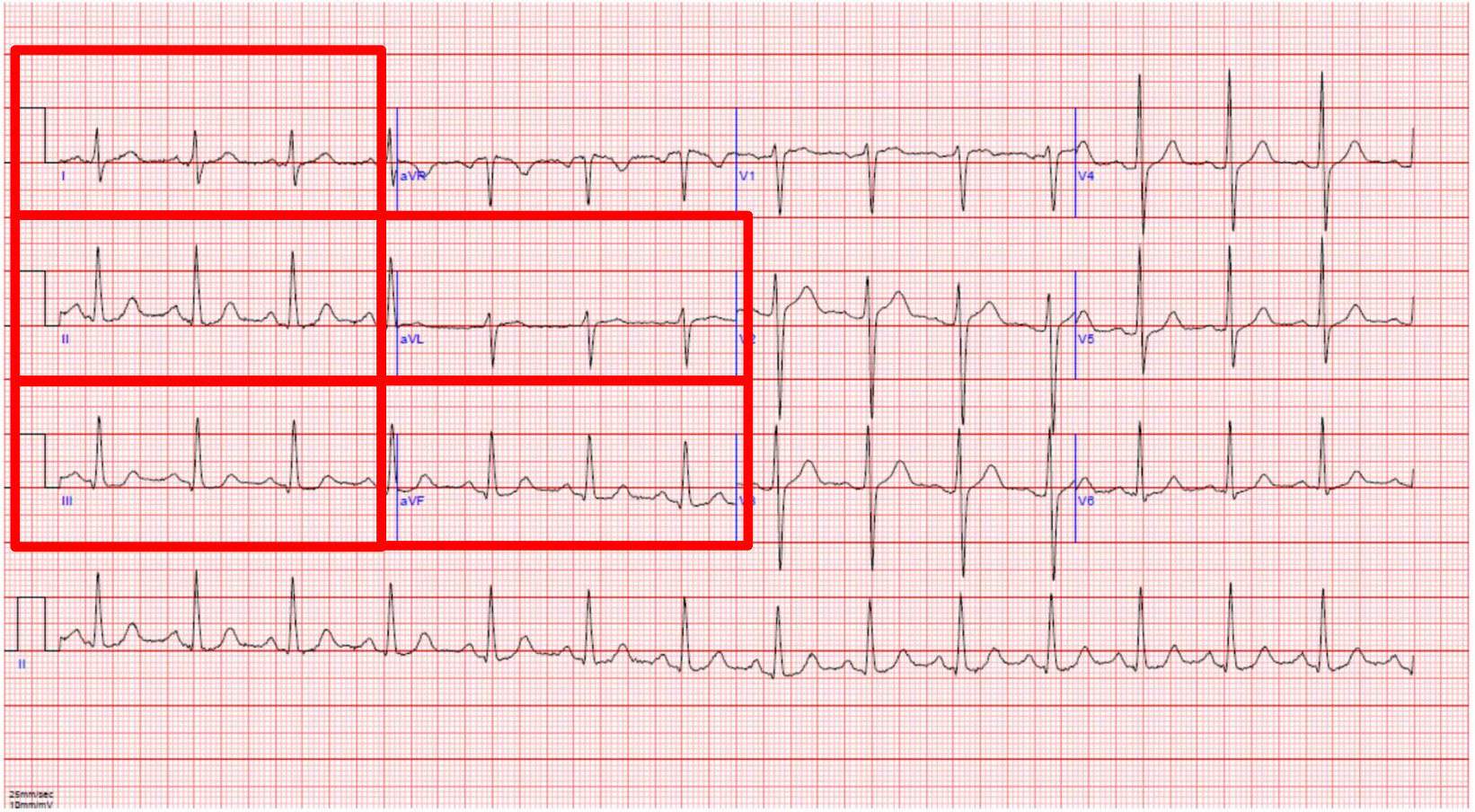
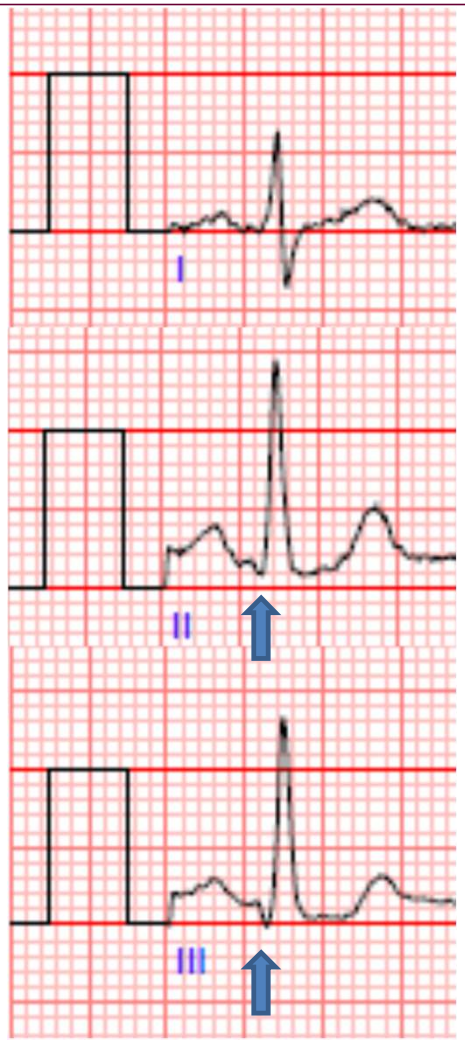
Morphologie



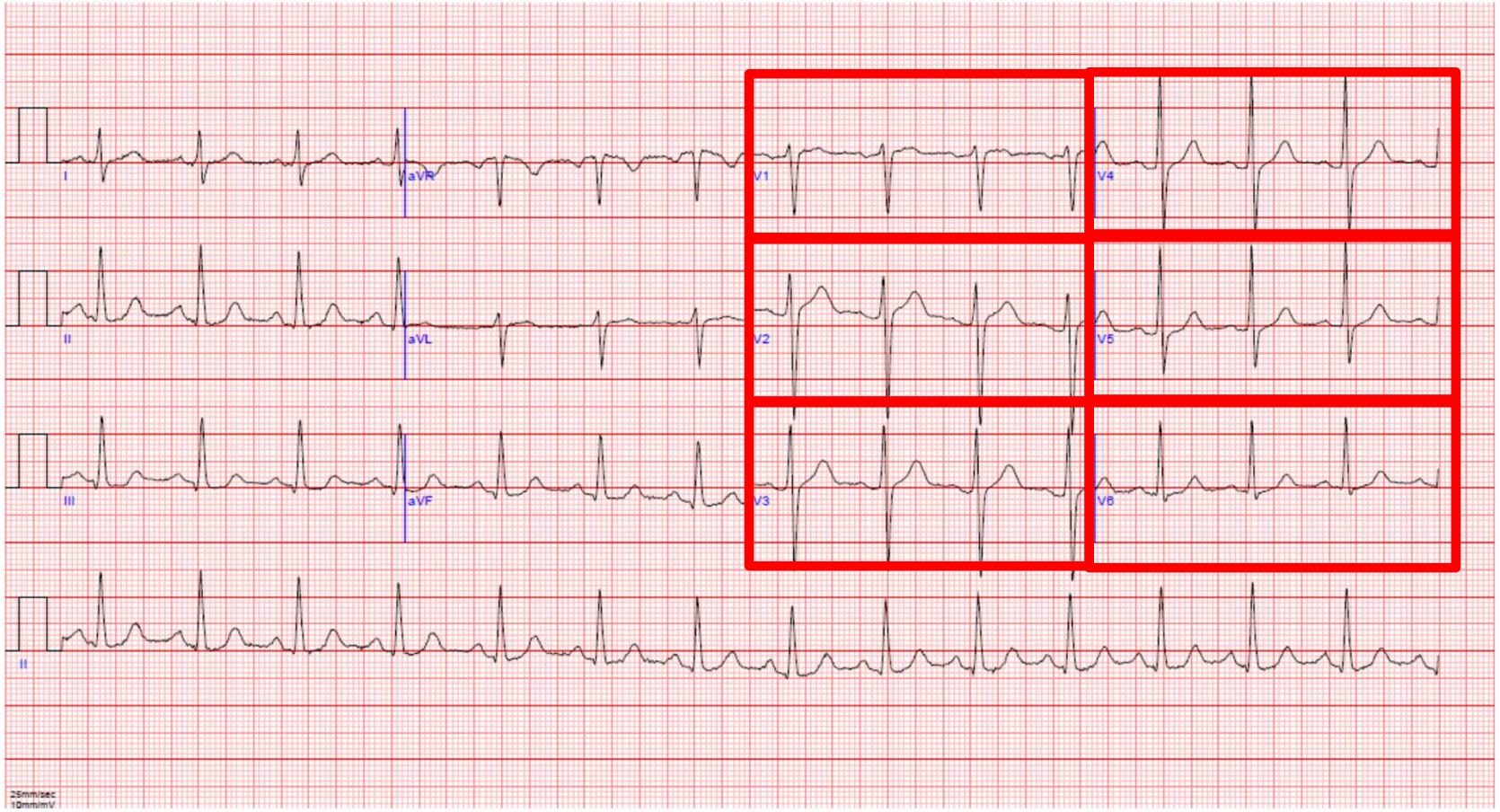
Morphologie périphérique



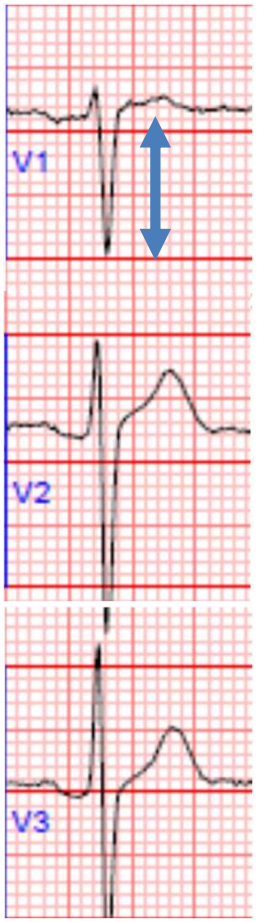
R < 11mm

q< ¼ R
< 1 carrée

Morphologie



Morphologie QRS precordial

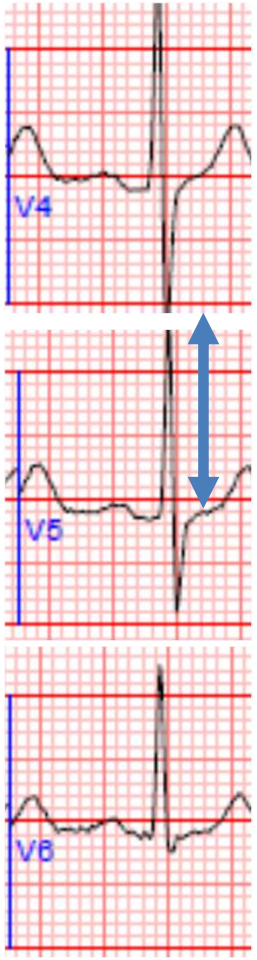


r<S

Pas de Q

Pas de Q

Compl.
Transition



BG1

SV1 + RV5/V6 <35 mm

q< ¼ R
< 1 carrée

Slide 28

BG1 Bernhard Gerber, 04/10/2020

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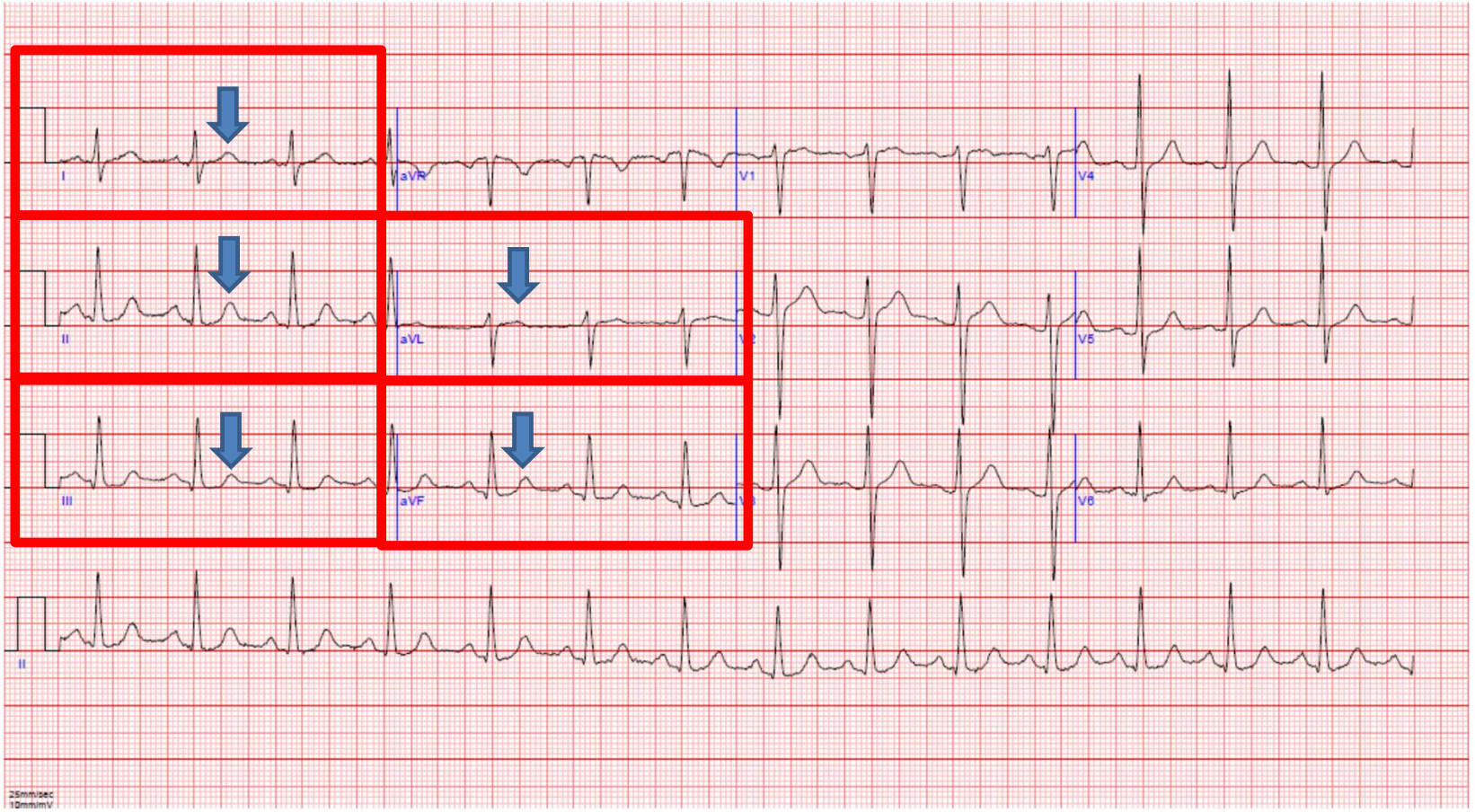
Repolarisation



Repolarisation périphérique

ST iso
T +

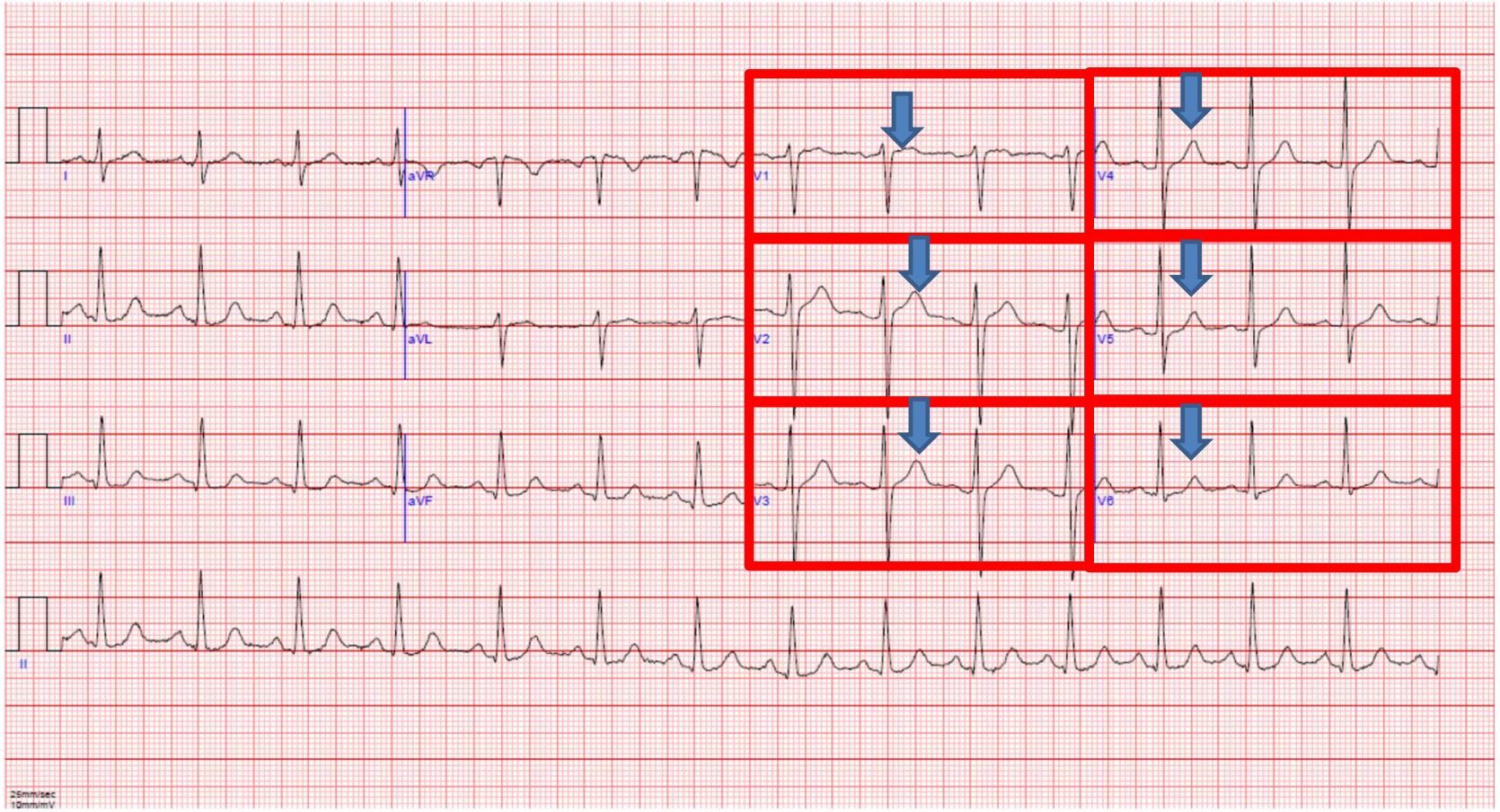
ST iso
T +

ST iso
T + ou -

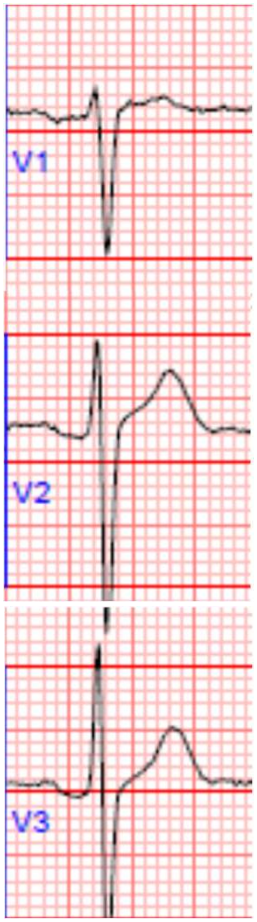
ST iso
T +

ST iso
T +

Morphologie



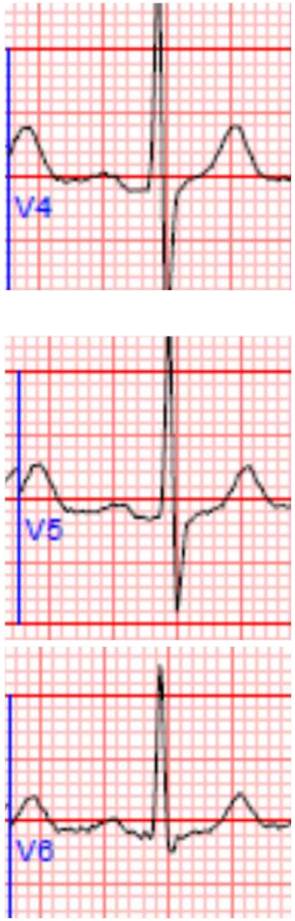
Repolarisation précordiale



ST iso
T + ou – si jeune

ST iso
T +

ST ascendant
Susdec rep pr
T +

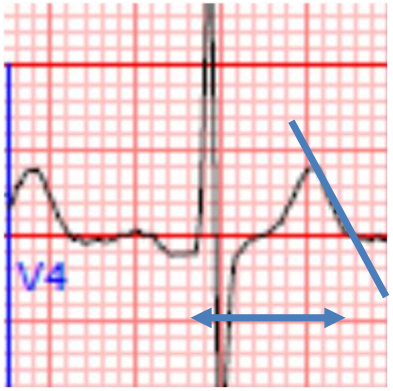


ST ascendant
Susdec rep prec
T +

ST iso
T +

ST iso
T +

QT



QTc < 450 ms

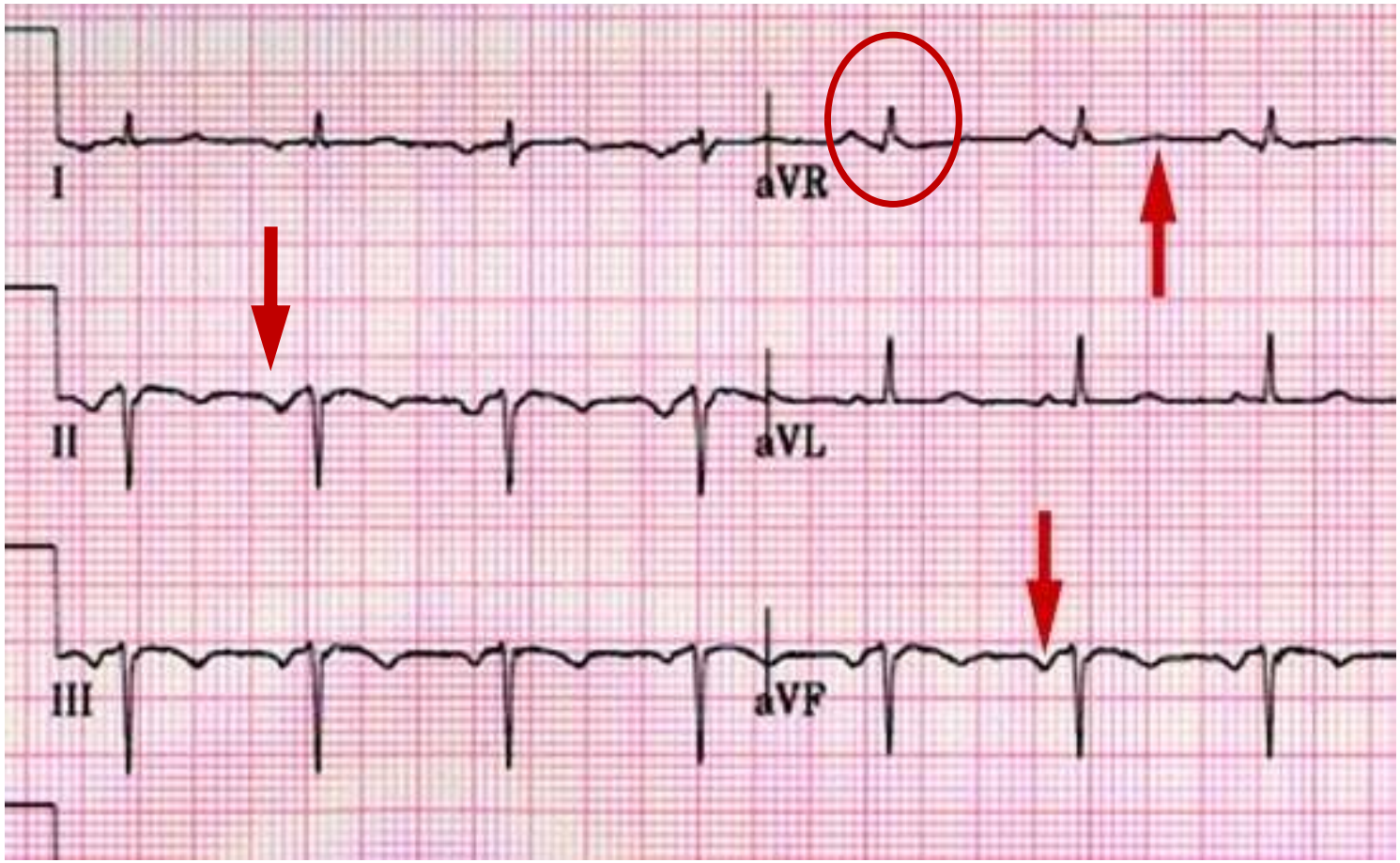
Fc 50: QT < 500 ms: 2 gd carrées ½
Fc 80: QT < 400 ms: 2 gd carrées

Résumé Analyse ECG

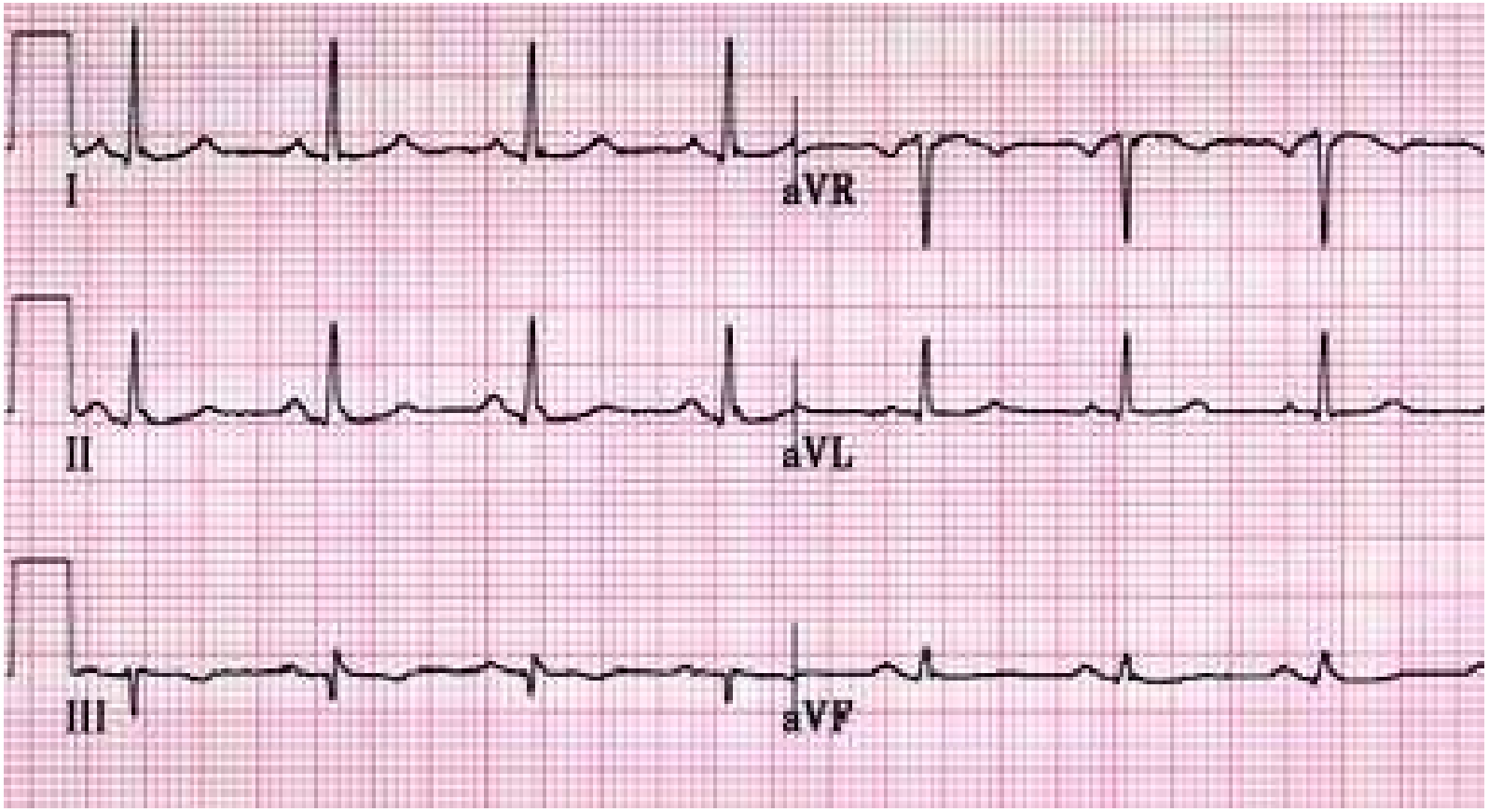
1. Rythme
   a) Fréquence — **60-100 bpm**
   b) Régularité — **régulier**
   c) Origine du rythme — **sinusal (onde P+ en DII, - aVR , +- V1)**
2. Dépolarisation auriculaire (P) — **+ en DII, <2 carrées haut, <3 carrée large**
3. Conduction auriculo-ventriculaire (PQ) — **< 200 (1 grand carrée)**
4. Dépolarisation ventriculaire (QRS)
   a) Durée — **<120 ms (3 petits carrées)**
   b) Axe Frontal — **0-90: + DI + aVF**
   c) Morphologie
      a) Dérivations Périphériques — **Voltages**
      b) Dérivation Précordiales — **Ondes q<1 carré**
         - **V1: r/S <1**
         - **R avL<11**
         - **SV1 + RV5/6 <35**
5. Repolarisation ventriculaire
   a) ST — **isoelectrique**
   b) T — **positif partout**
   c) QTc
   d) U — **< 2 grands carrées**

PIEGES

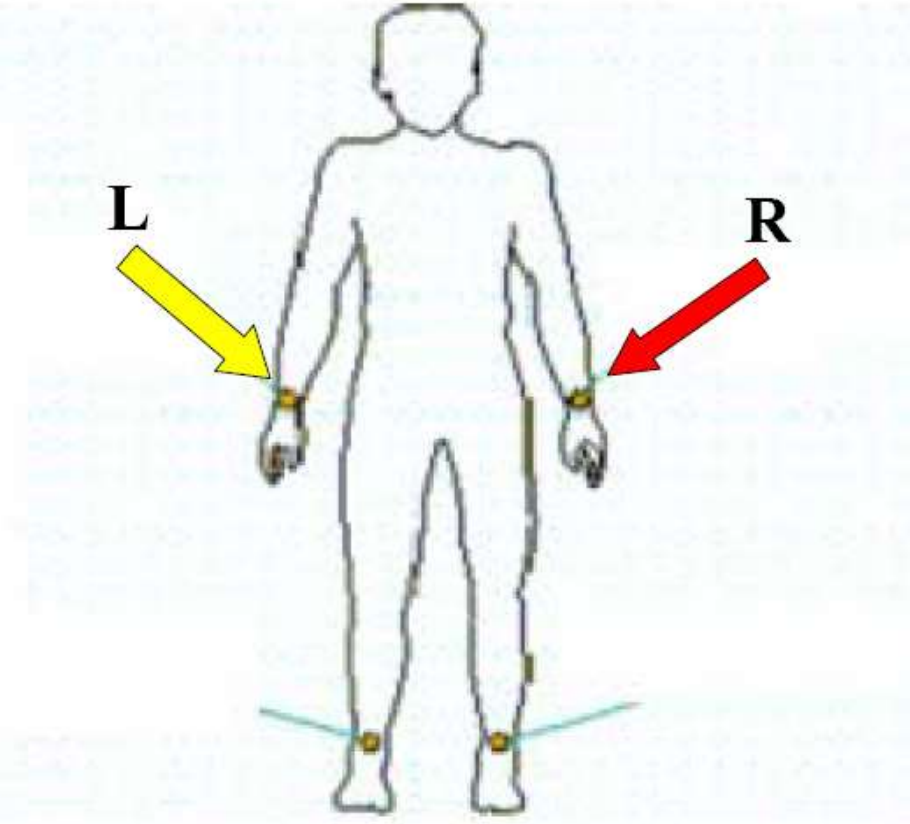
Piège : Inversion des électrodes



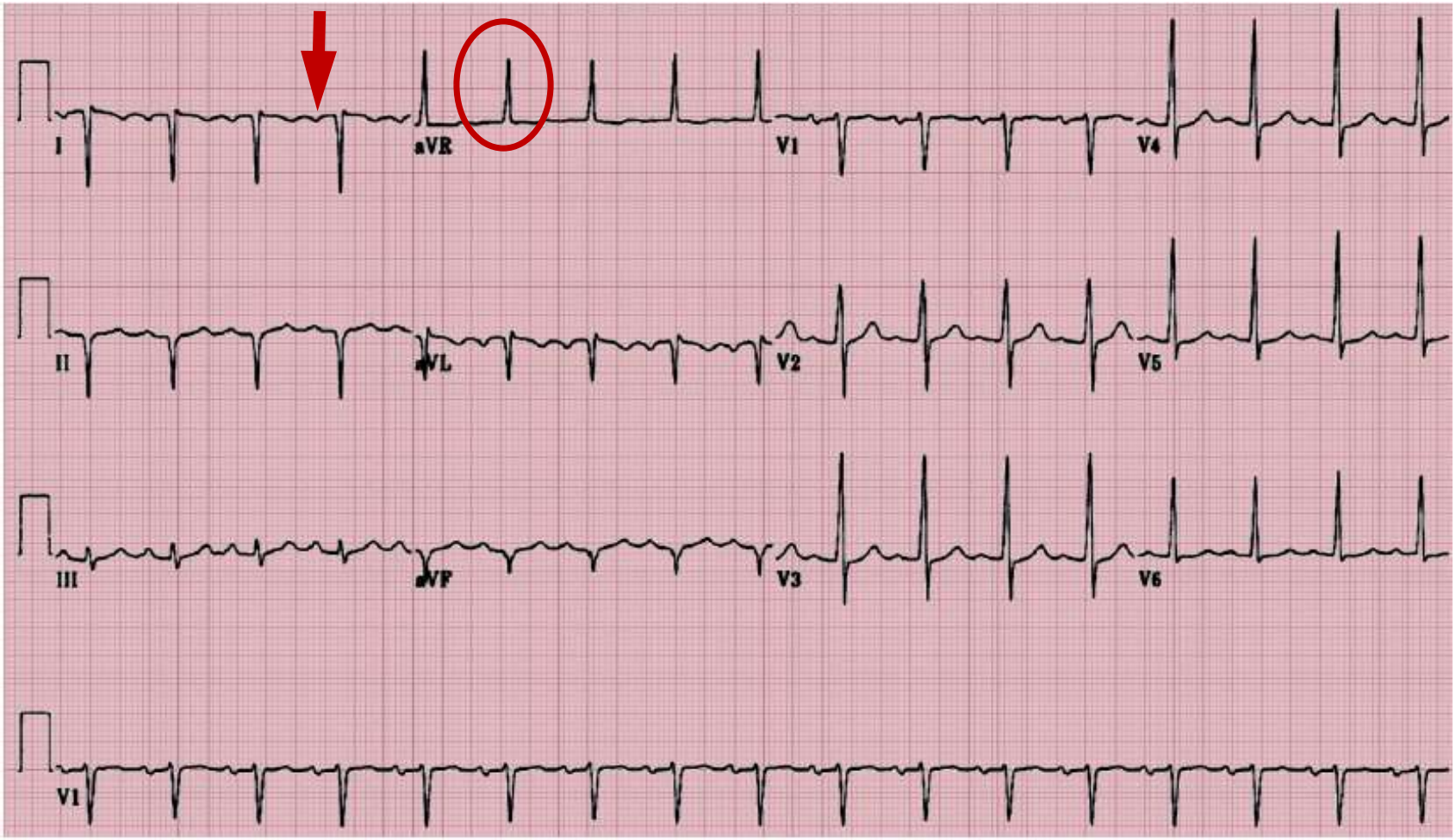
Même ECG: Electrodes corrects



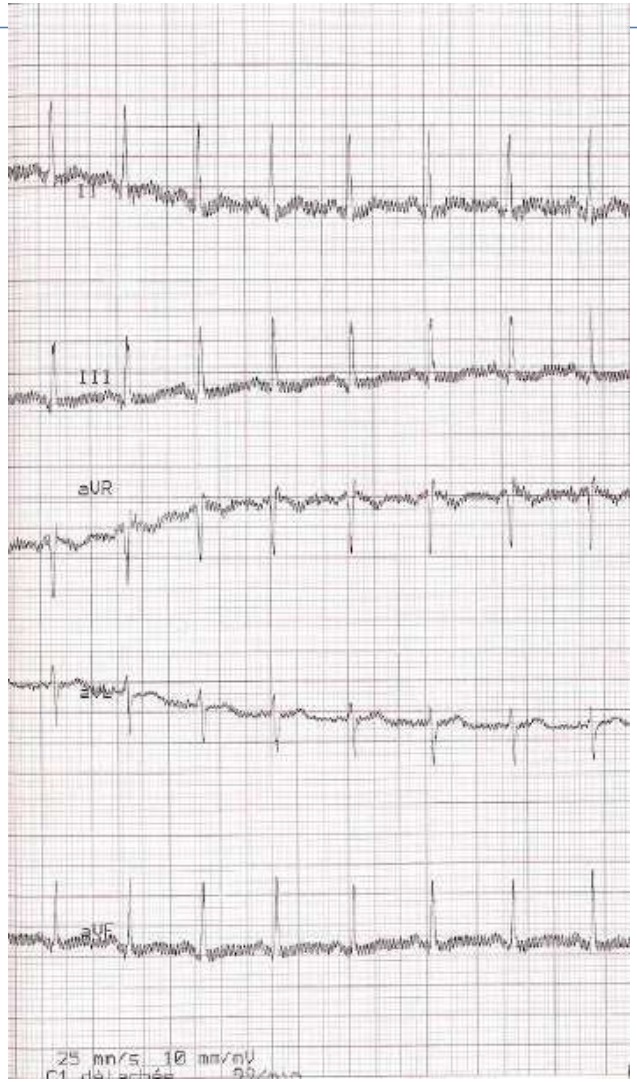
Inversion électrodes



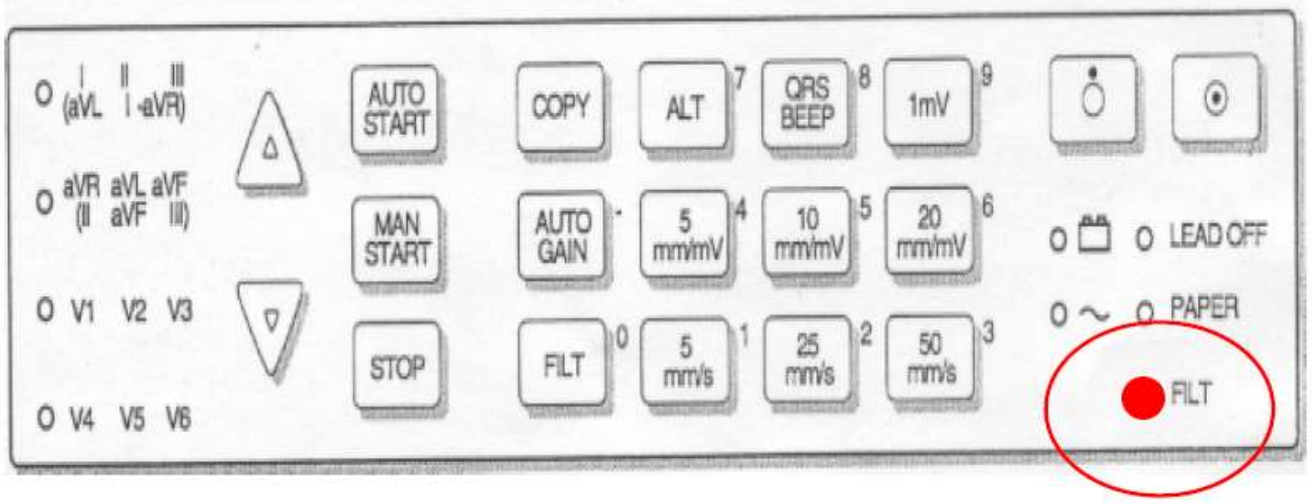
Autre cas inversion Electrodes



Artéfact: 50 Hz



Filtre 50 Hz


I (aVL) II III (-aVR)
aVR aVL aVF (II aVF III)
V1 V2 V3
V4 V5 V6
AUTO START
MAN START
STOP
COPY
AUTO GAIN
FILT
ALT
5 mm/mV
5 mm/s
QRS BEEP
10 mm/mV
25 mm/s
1mV
20 mm/mV
50 mm/s
LEAD OFF
PAPER
FILT

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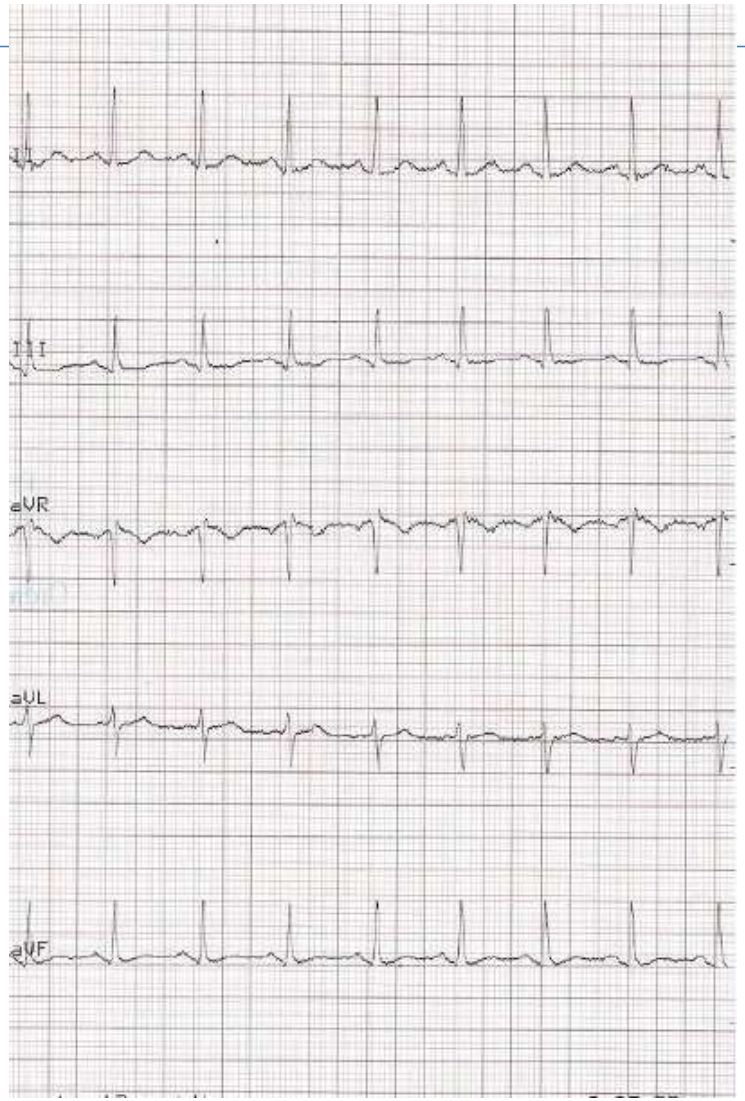
ECG Filtrée



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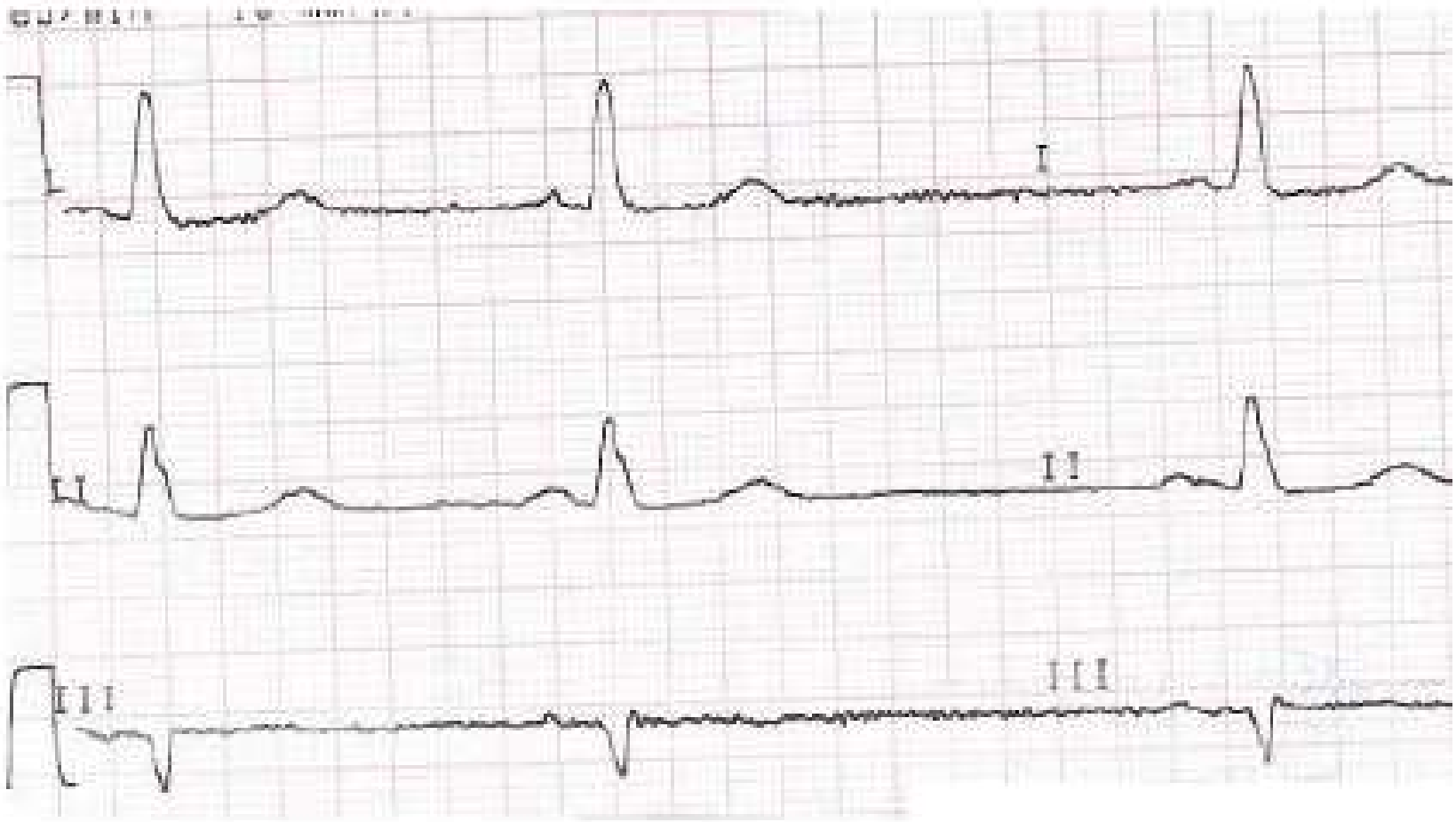
de Louvain

Piège: vitesse mal choisie



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Vitesse correcte

25 mm/sec

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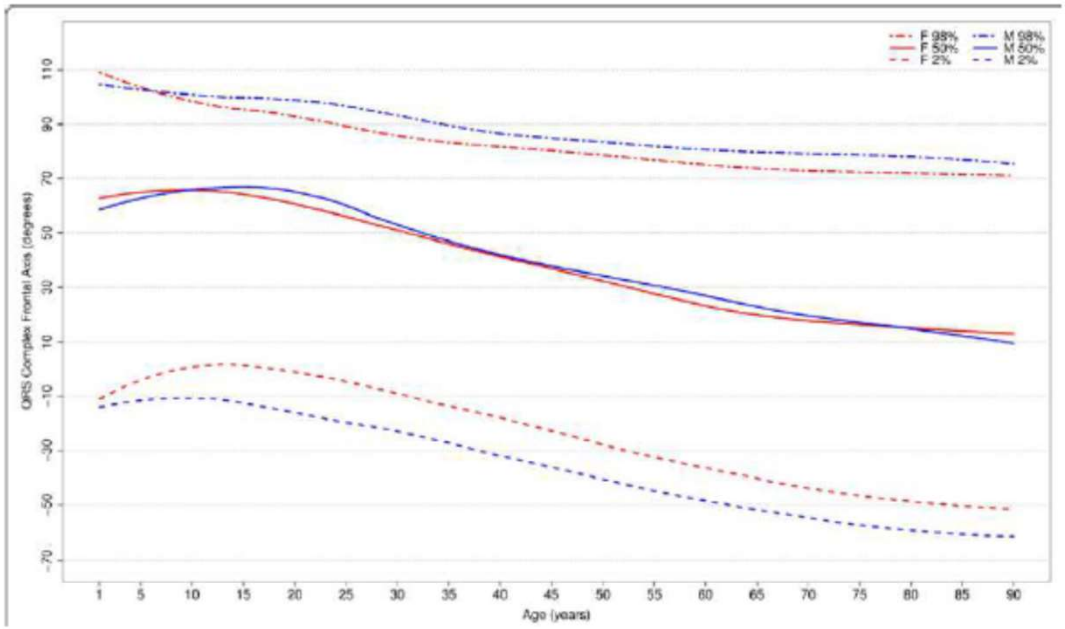
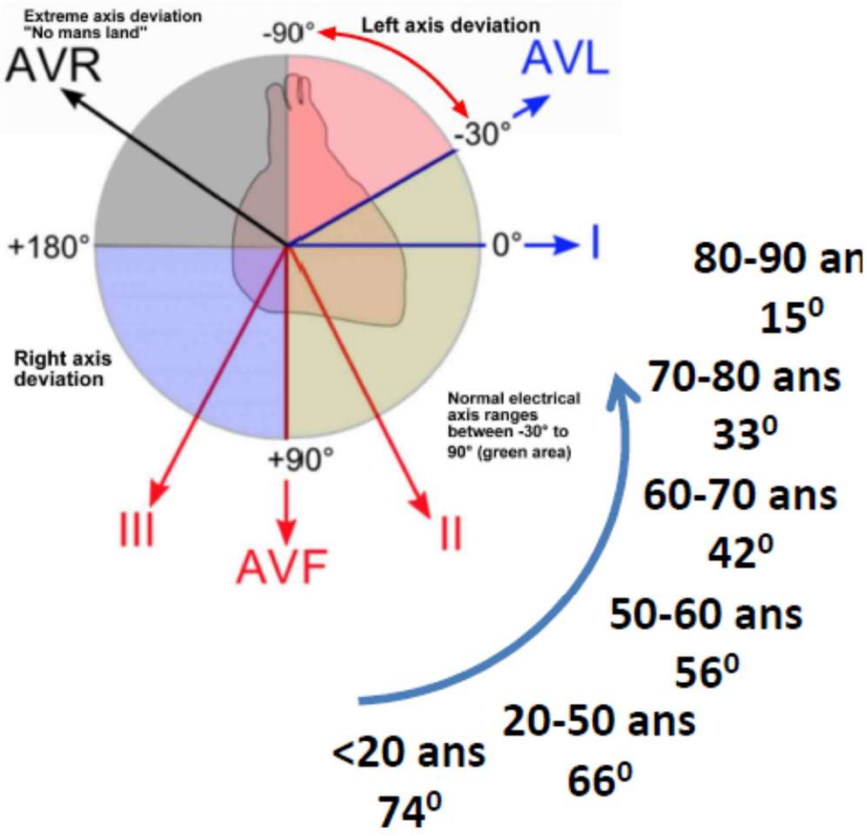
Artéfact respiratoire

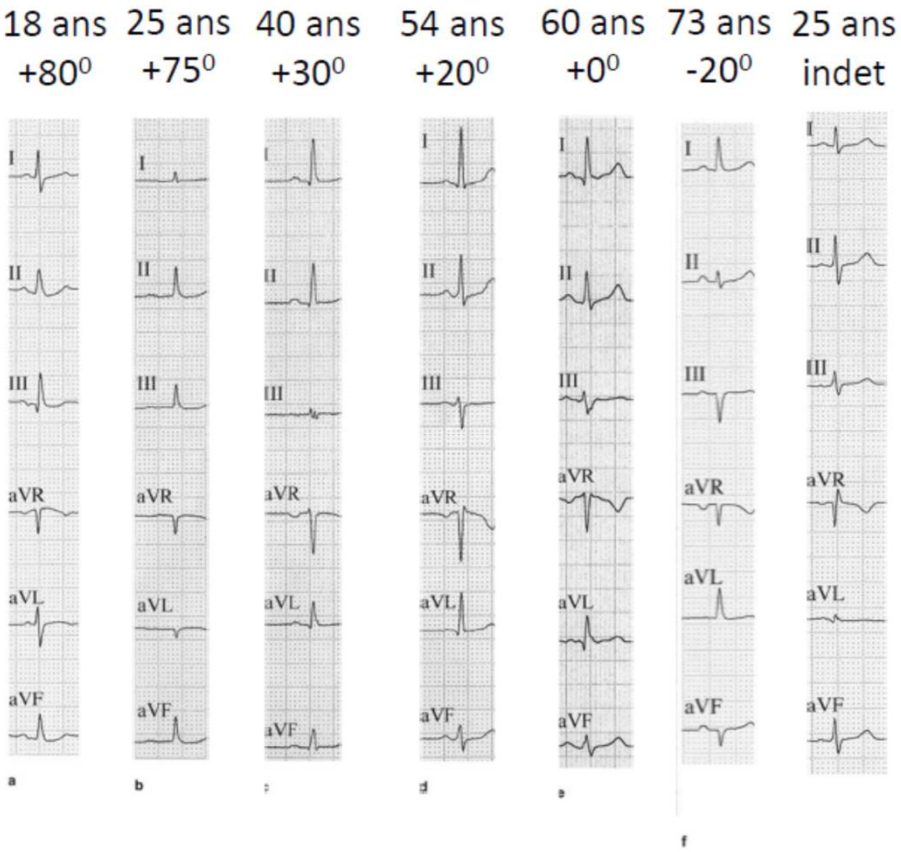
VARIANTES NORMALES

Axe QRS Influence de l'age

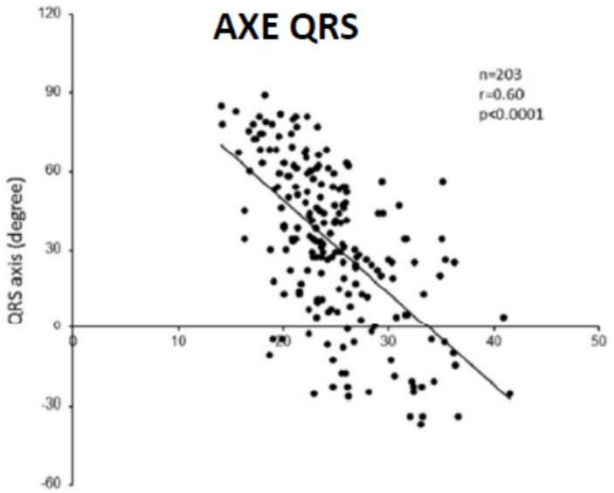


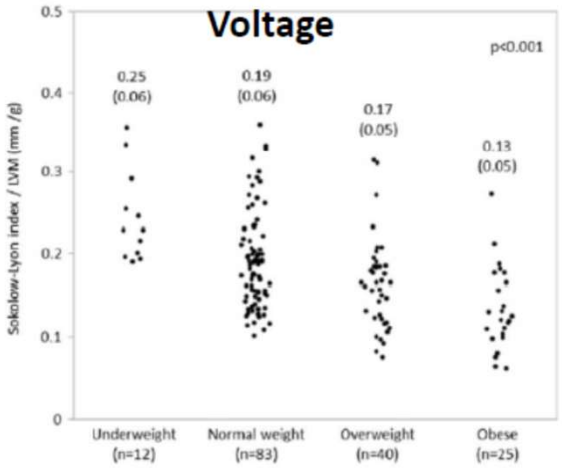


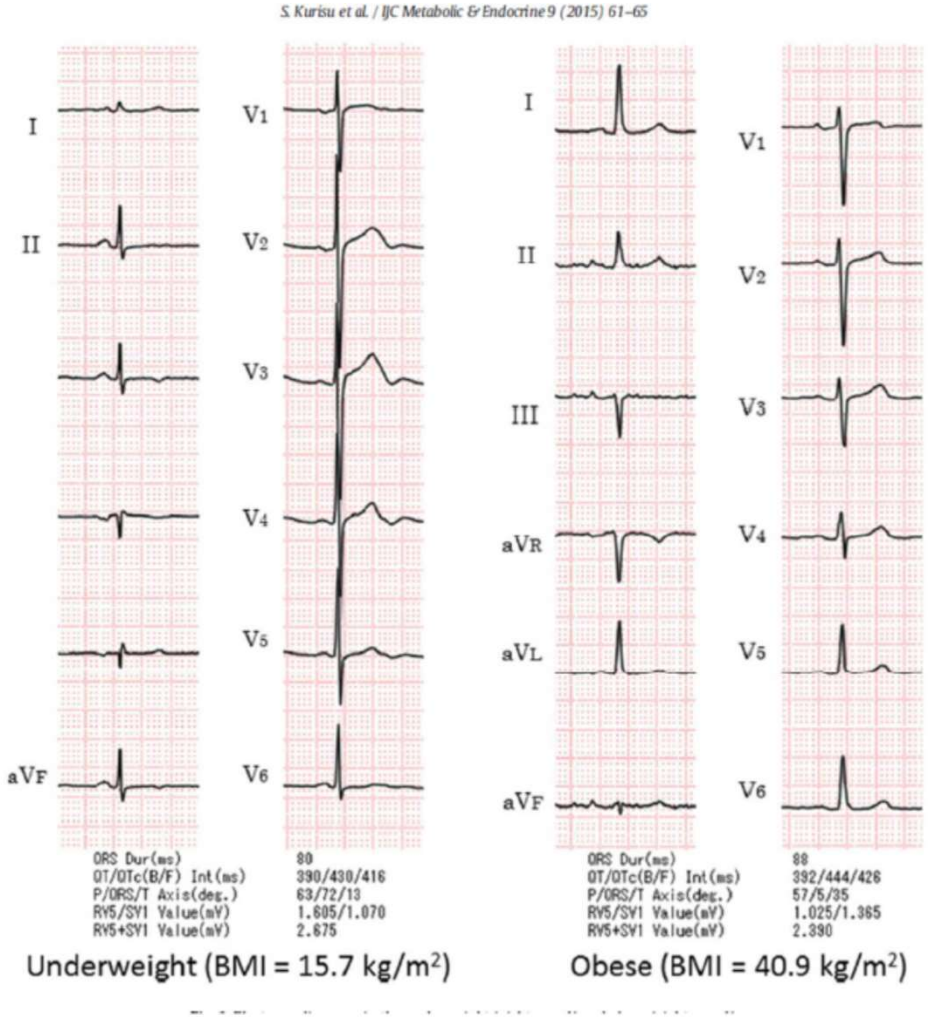
Axe QRS vs Age



ECG vs Poids


AXE QRS
n=203
r=0.60
p<0.0001
QRS axis (degree)
Body mass index (kg/m²)


Voltage
p<0.001
Sokolow-Lyon index / LVM (mm /g)
0.25 (0.06)
0.19 (0.06)
0.17 (0.05)
0.13 (0.05)
Underweight (n=12)
Normal weight (n=83)
Overweight (n=40)
Obese (n=25)


S. Kurisu et al. / IJC Metabolic & Endocrine 9 (2015) 61–65
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
ORS Dur(ms) 80
QT/QTc(B/F) Int(ms) 390/430/416
P/QRS/T Axis(deg.) 63/72/13
RV5/SV1 Value(mV) 1.605/1.070
RV5+SV1 Value(mV) 2.675
ORS Dur(ms) 88
QT/QTc(B/F) Int(ms) 392/444/426
P/QRS/T Axis(deg.) 57/5/35
RV5/SV1 Value(mV) 1.025/1.365
RV5+SV1 Value(mV) 2.390
Underweight (BMI = 15.7 kg/m²)
Obese (BMI = 40.9 kg/m²)

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Variantes normales

- Rythme
  - Bradycardie sinusale (sportif)
  - Arrythmie sinusale
  - Tachycardie approprié
- Axe
  - Déviation axiale droite chez l'adolescent
  - Rotation horaire / antihoraire
- Repolarisation précoce
- Absence de progression de l'onde R
- Hypervoltage chez des patients maigres
- Microvoltage chez l'obèse
- Onde Q isolée en III
- BBDincomplet (RSr') V1
- T- en DIII
- T- V1
- QS V1
- Q aVL (Coeur vertrical)
- Q inférieur et lateral enfants

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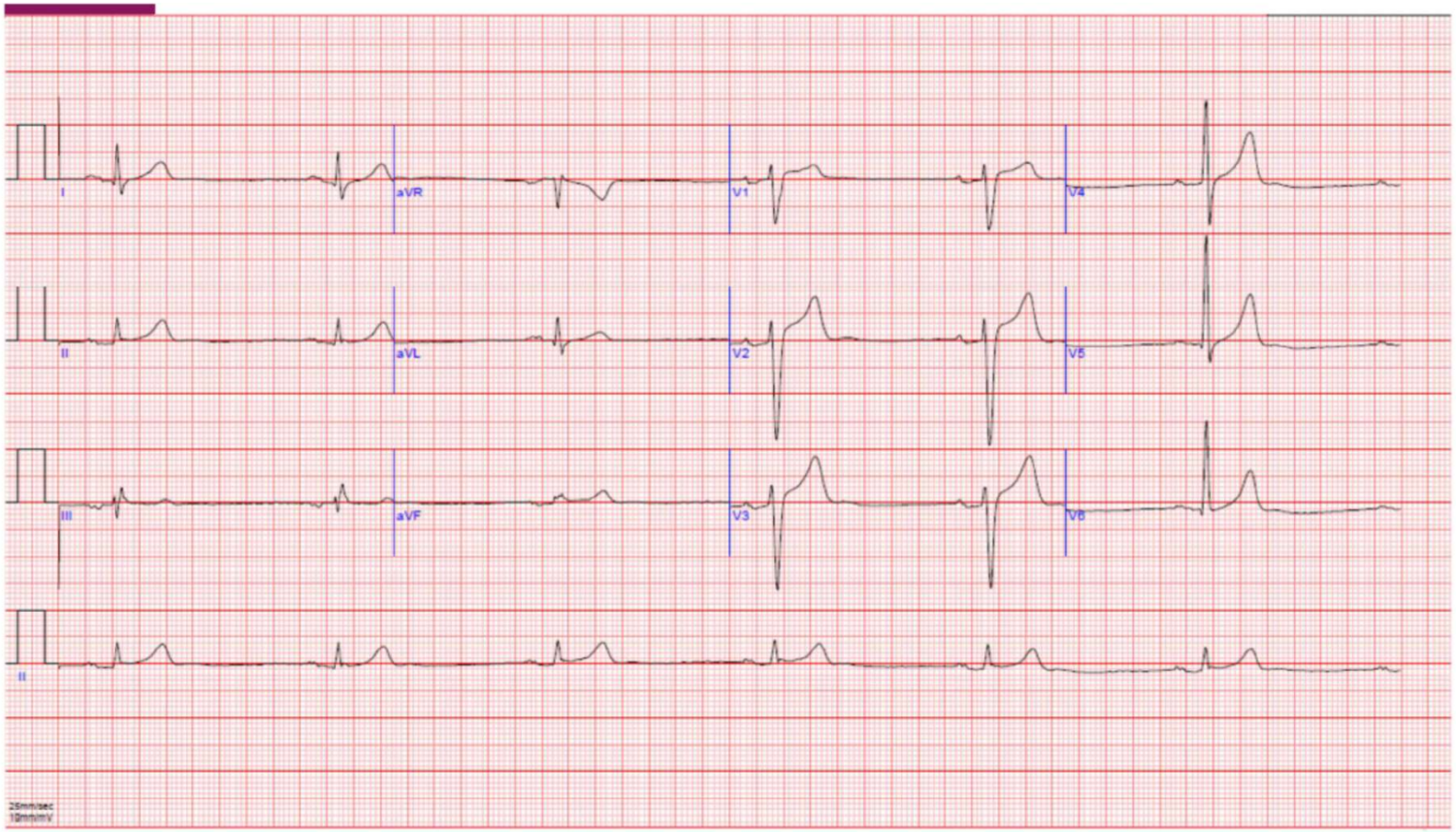
Bradycardie sinusal



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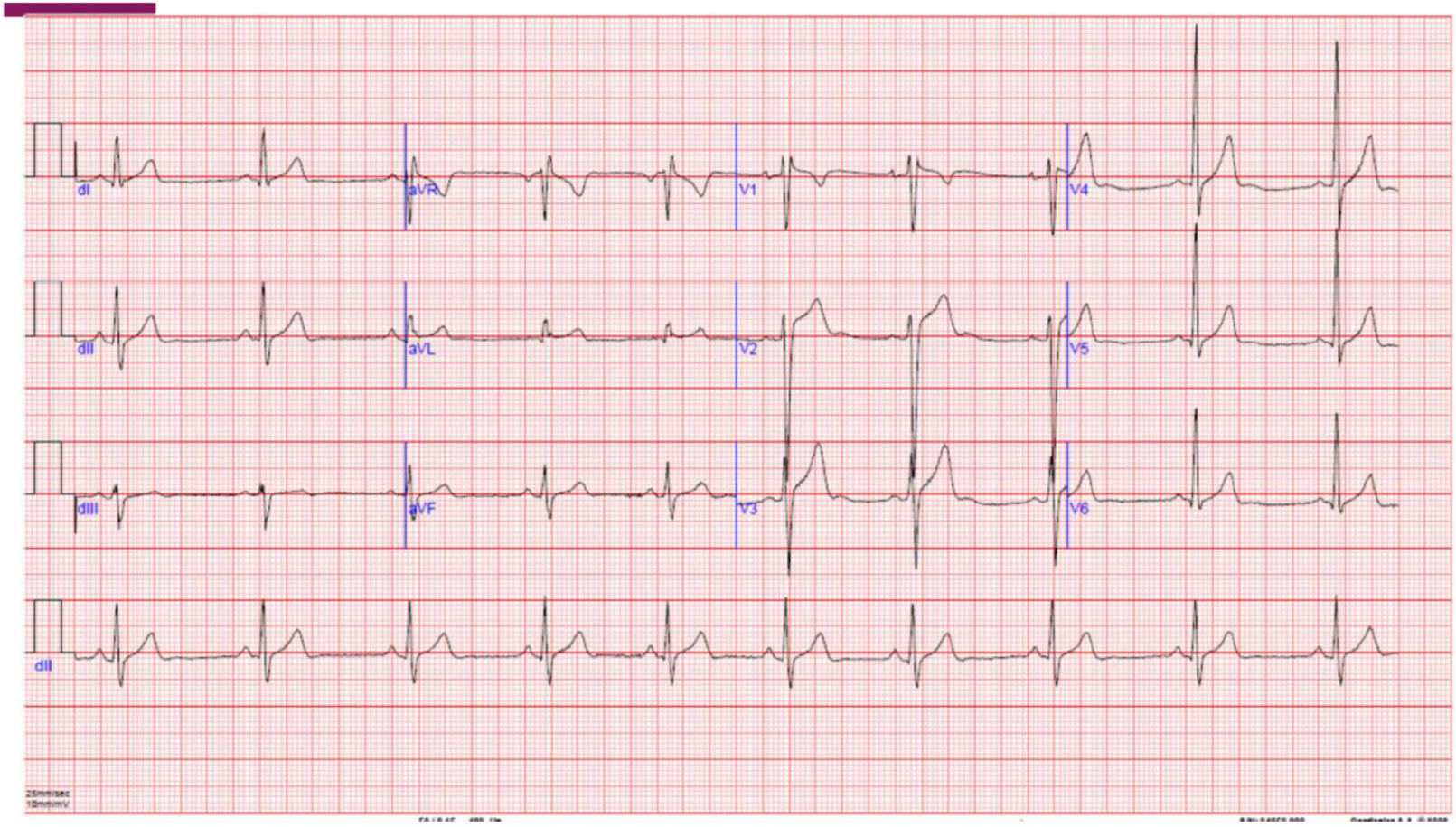
Arrythmie sinusale



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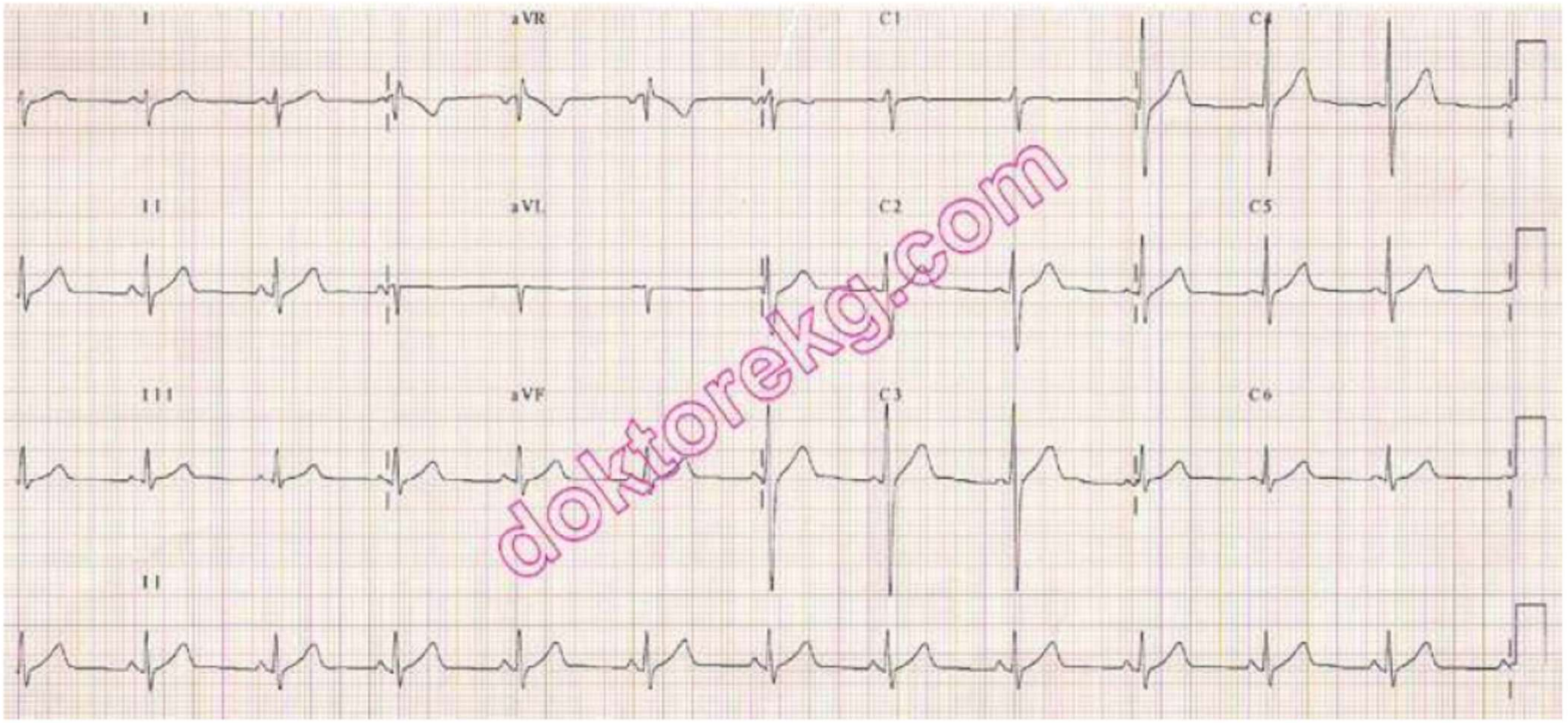
Axe droit (14 ans)

Axe QRS 100^0



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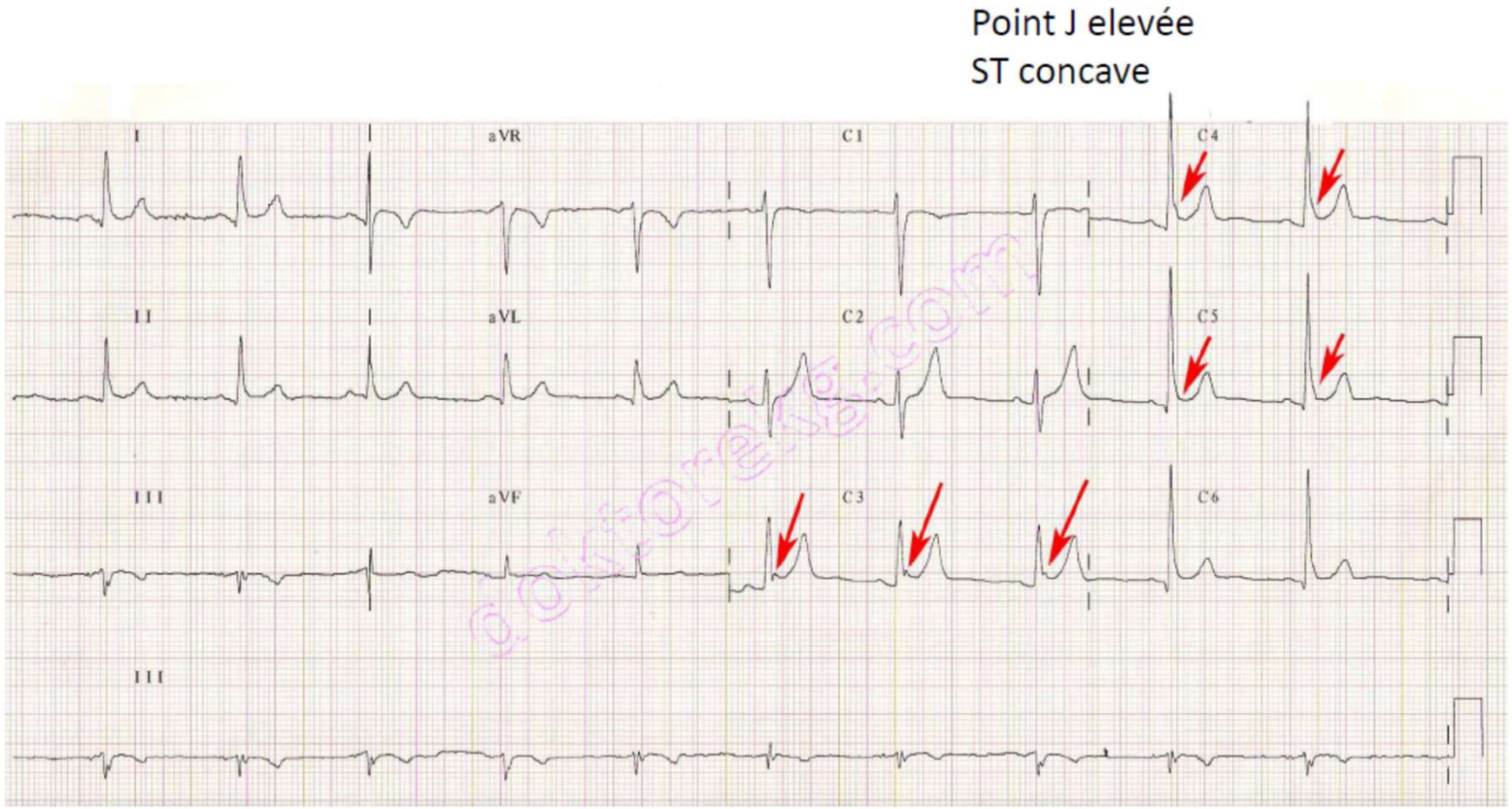
Repolarisation précoce



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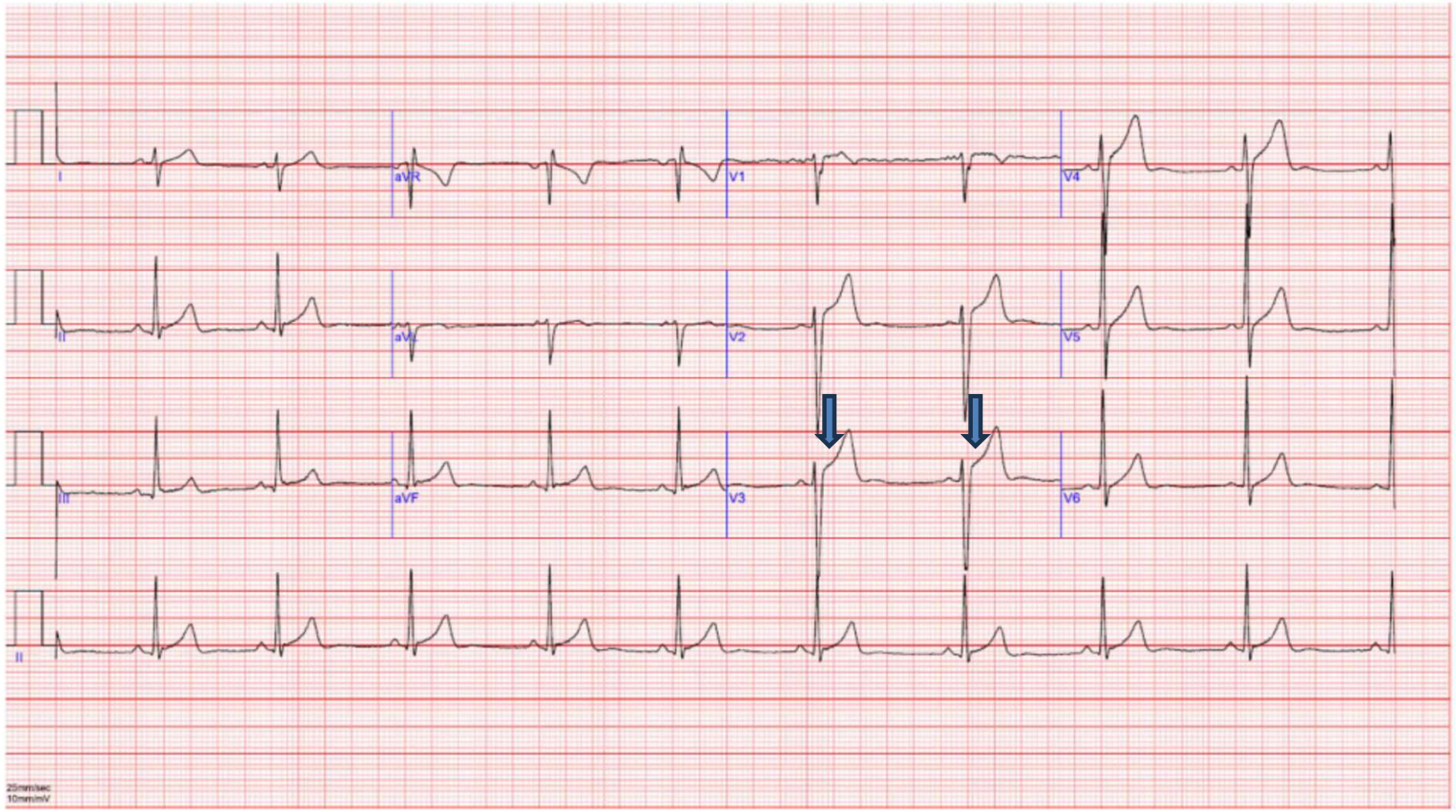
Repolarisation précoce



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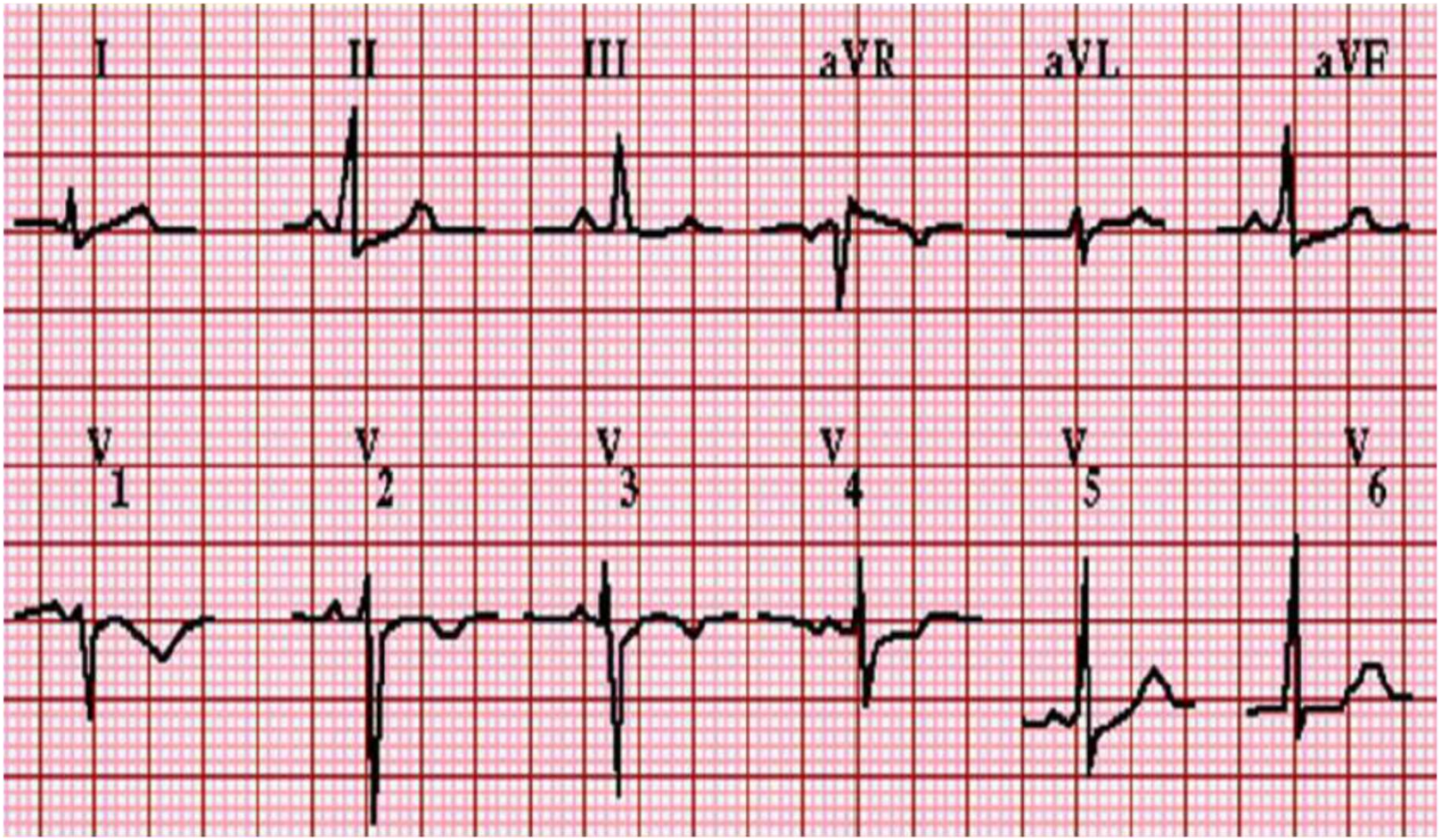
Pattern T- Juvénile (10 ans)



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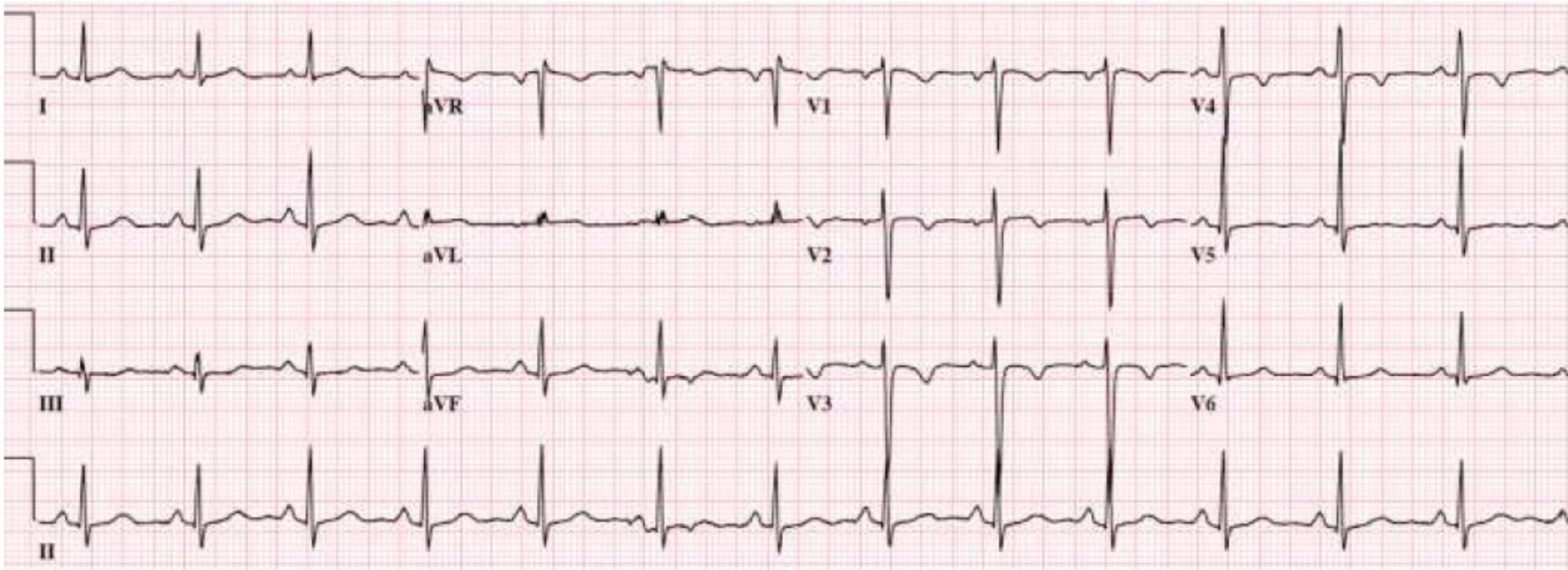
Pattern juvenile persistant



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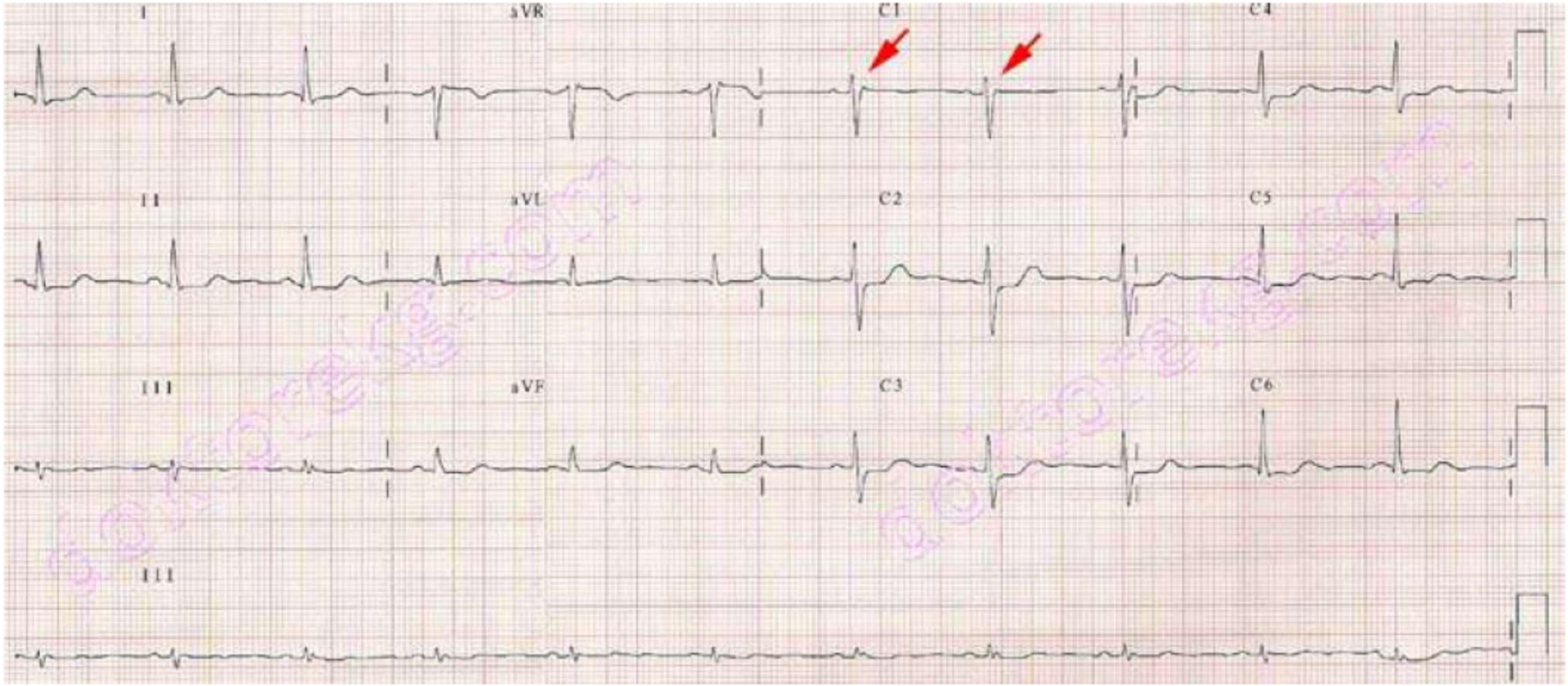
RSr'V1



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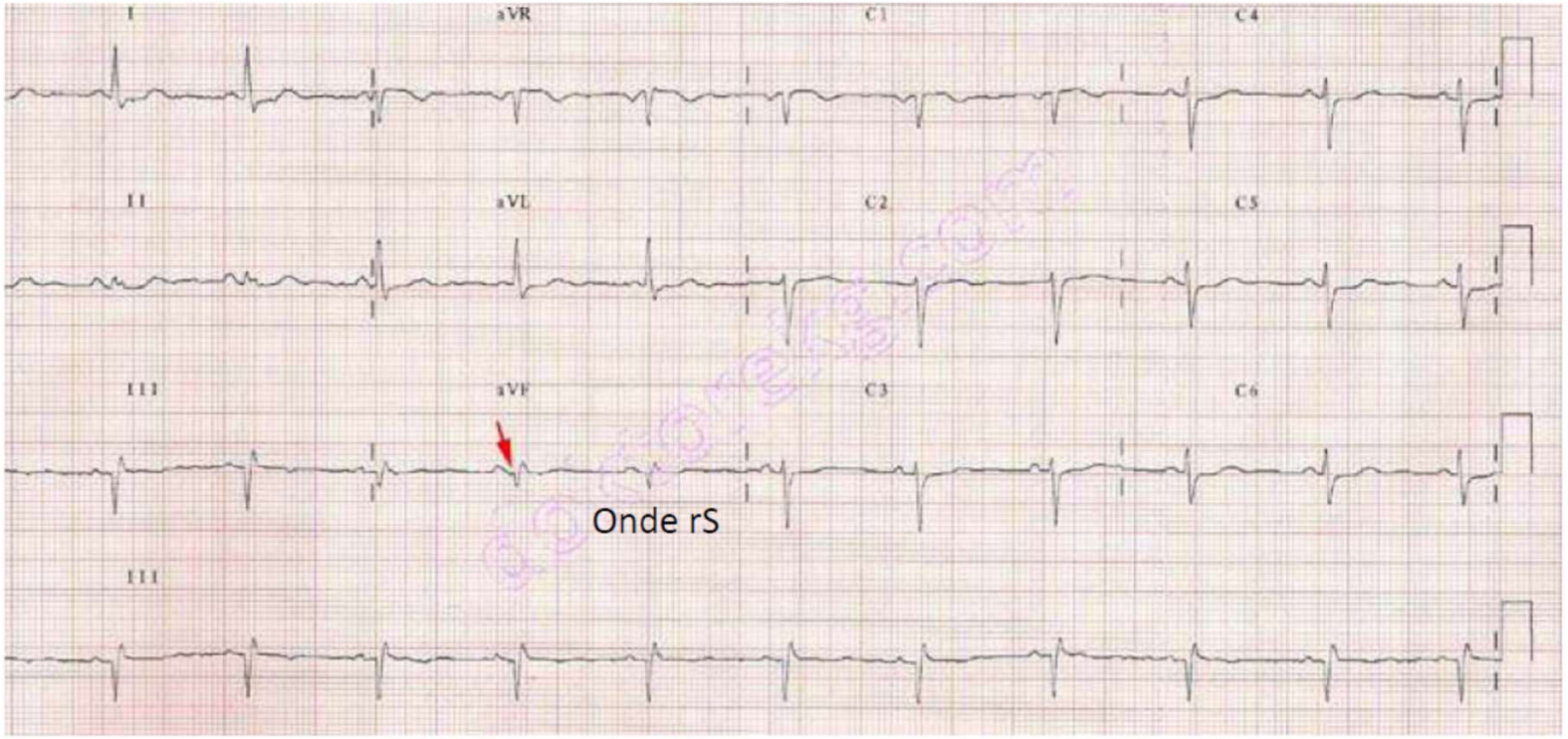
Ondes Q en DIII



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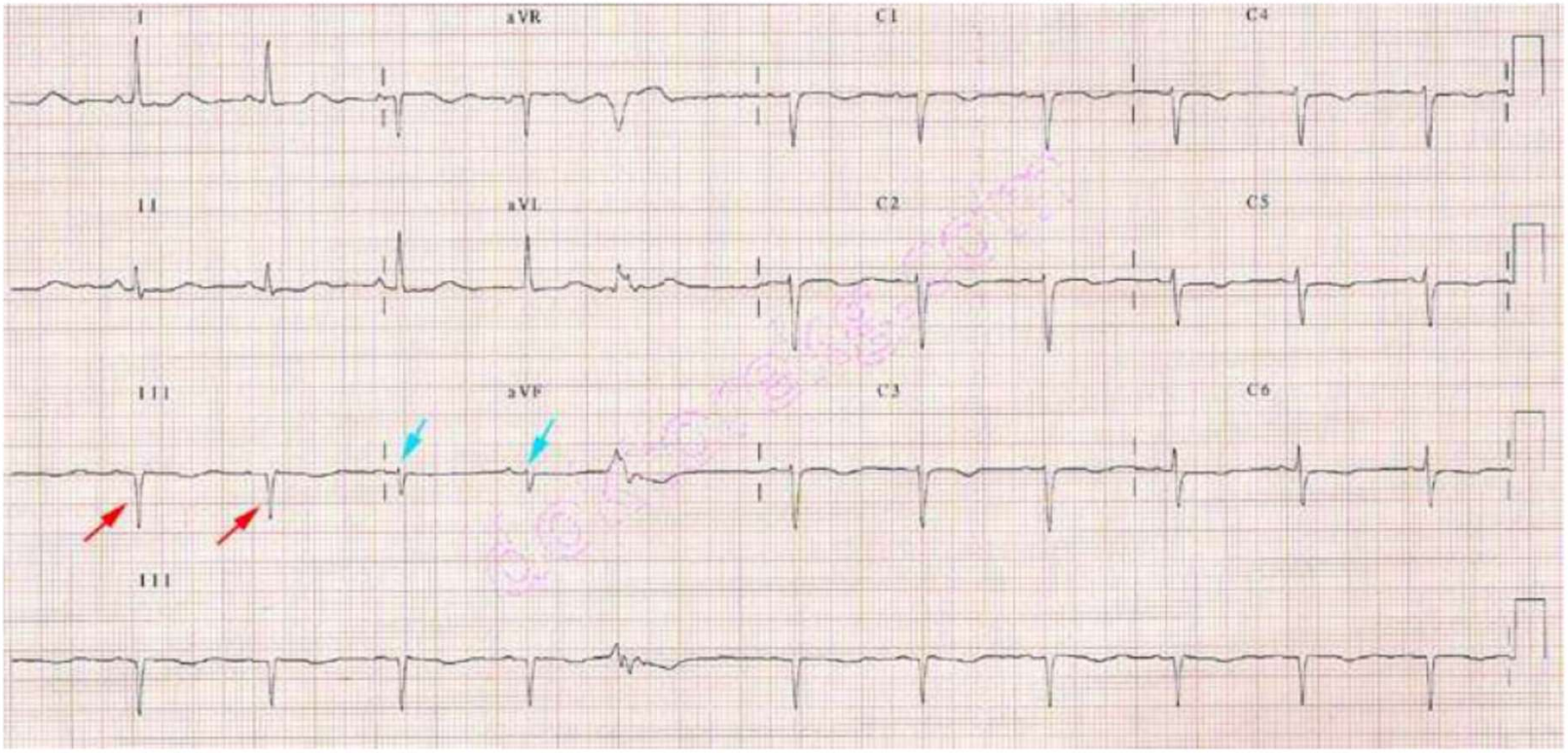
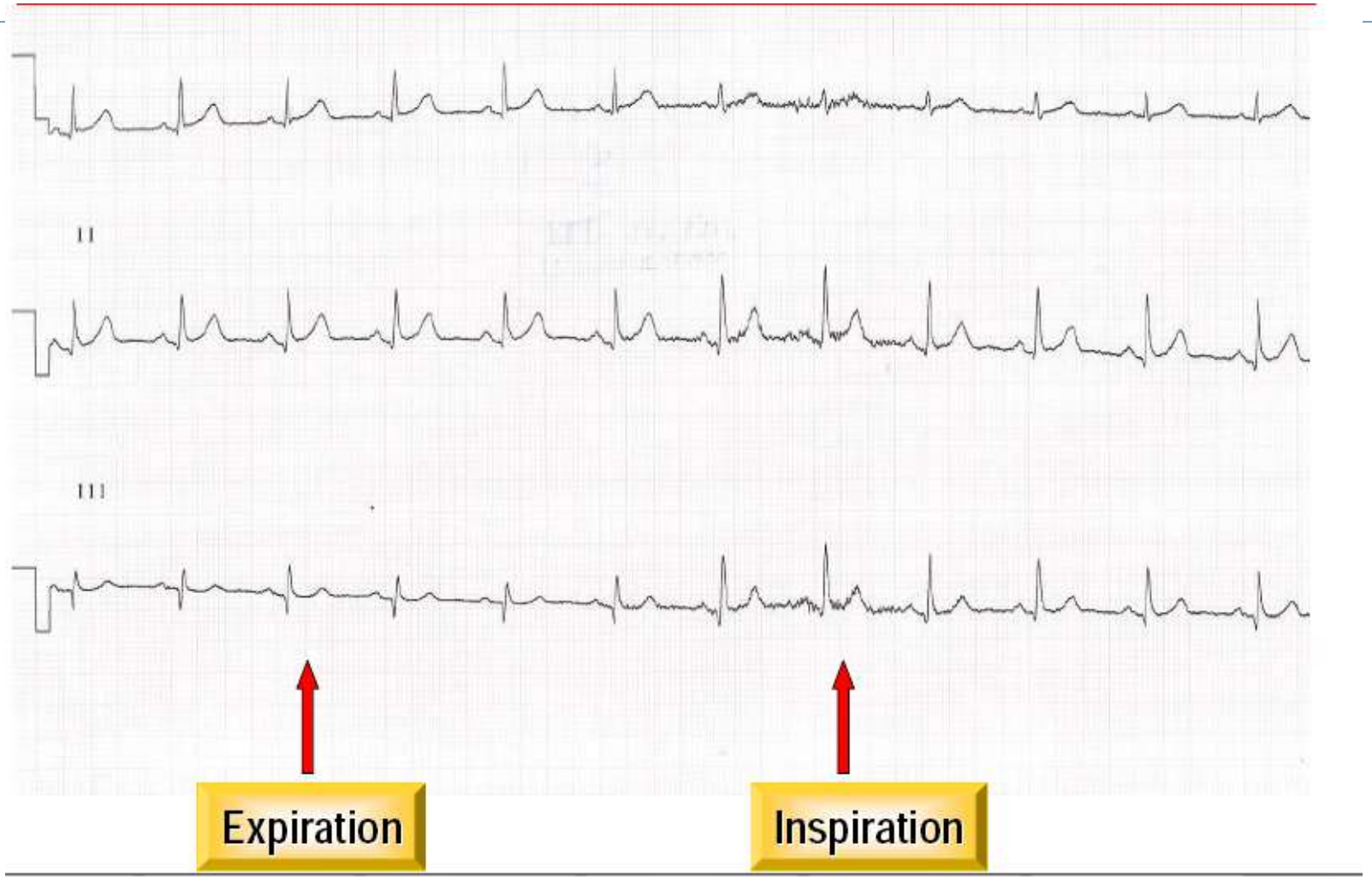
Onde Q en DIII



Ondes Q positionnelles



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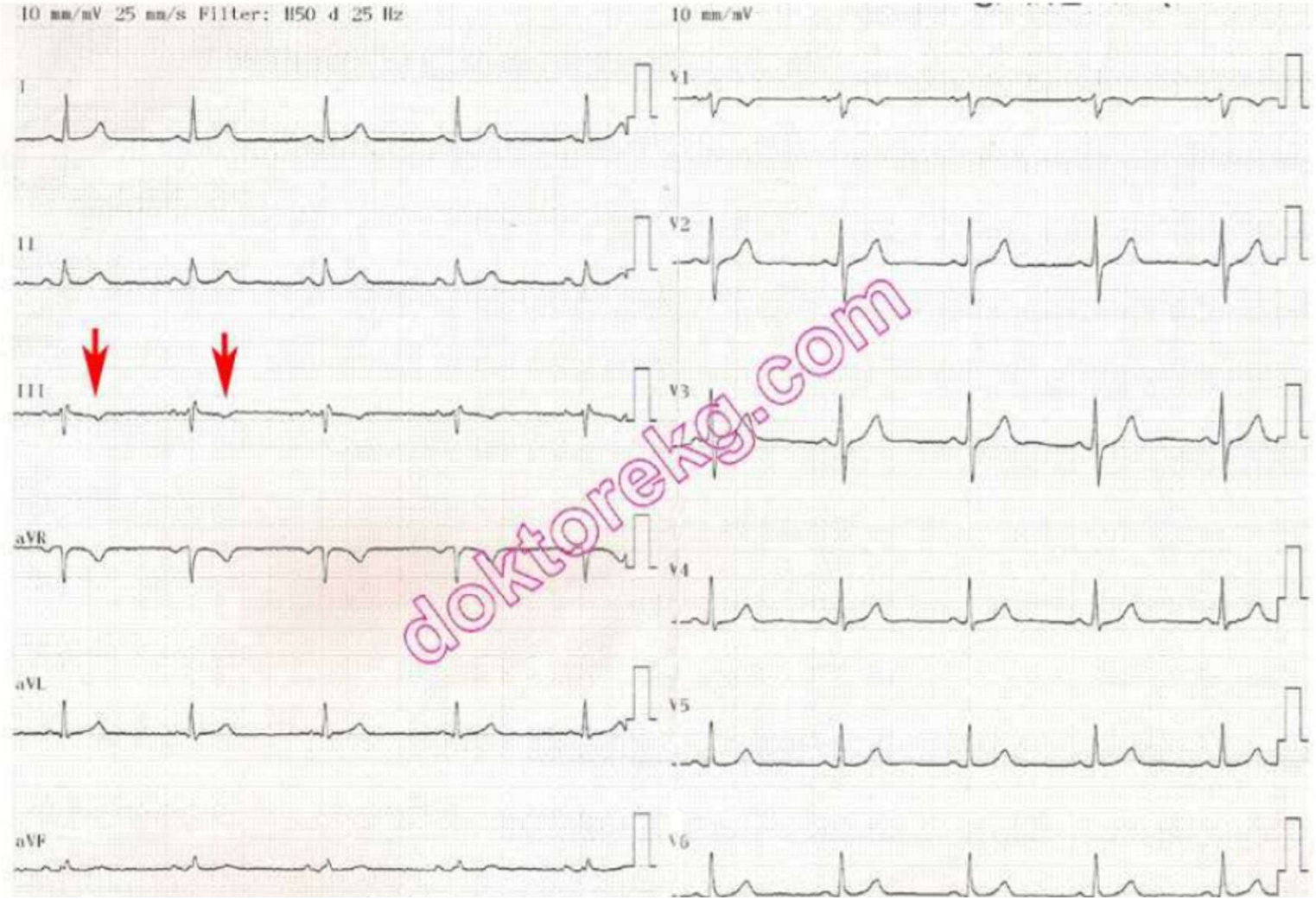
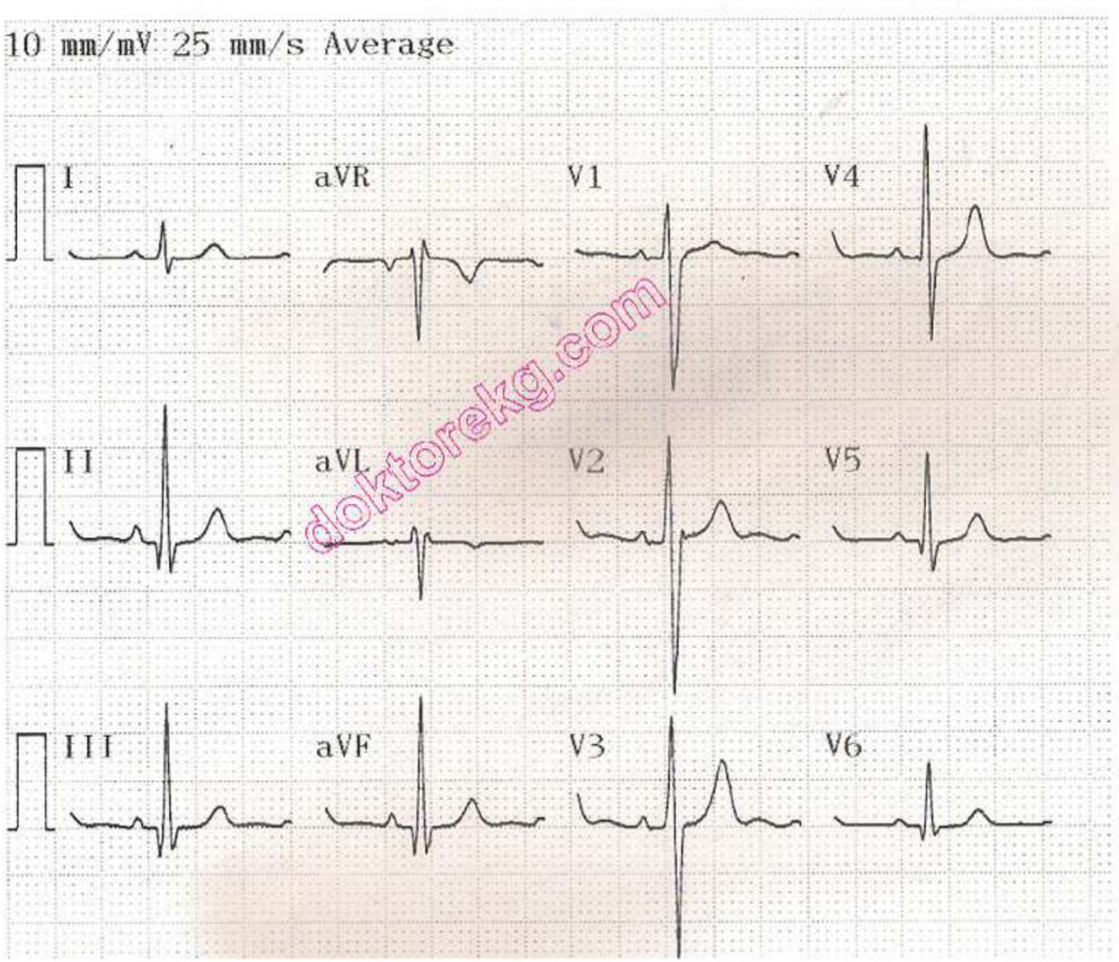
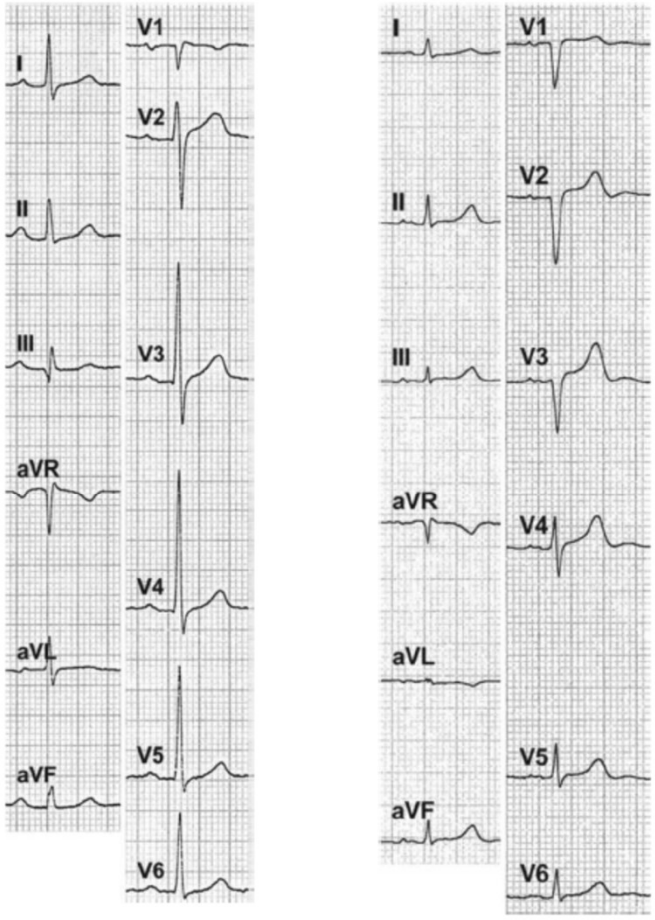
T- en DIII



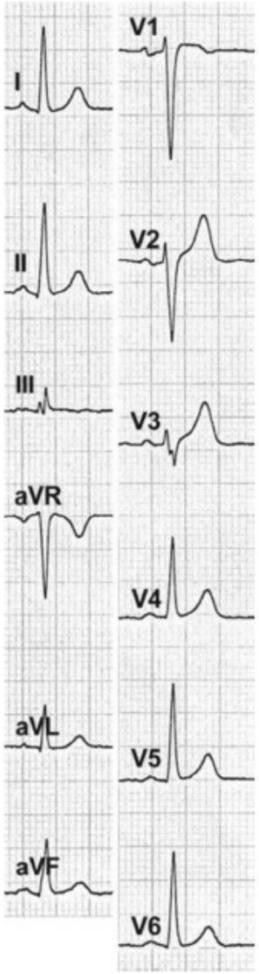
Hypervoltage maigre (18 ans)



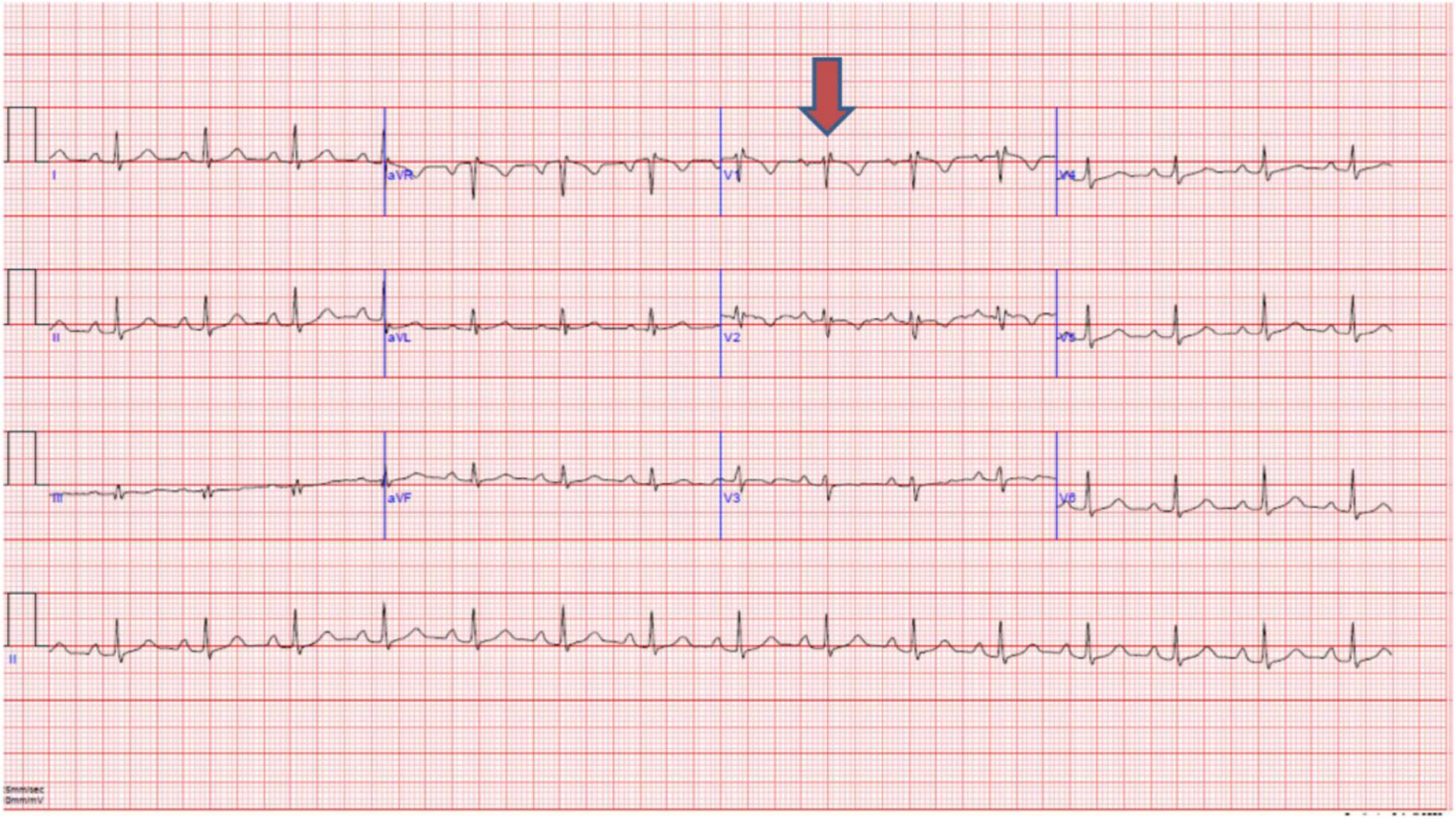
QS V1


I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6

Crochetage V3



BBD incomplet



ECG PÉDIATRIQUE

ECG pédiatrique normal
Fréquence cardiqaue

- Nouveau Né: 110 – 150 bpm
- 2 ans: 85 – 125 bpm
- 4 ans: 75 – 115 bpm
- 6 years+: 60 – 100 bpm

ECG pédiatrique normal
Axe QRS

- 1 sem – 1 mois: + 110° (+30° to +180°)
- 1 mois – 3 mois: + 70° (range +10° to +125°)
- 3 mois – 3 ans: + 60° (range +10° to +110°)
- > 3 ans: + 60° (range +20° to +120°)
- Adulte: + 50° (range -30° to 105°)

ECG pédiatrique
onde P

- Amplitude <3 mm
- Durée :
  - bébés: < 70 ms
  - Enfants: < 90 ms

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ECG Pédiatrique
Intervalle PR

Rate (bpm)	0-1 month	1-6 month	6-12 month	1-3 year	3-8 year	8-12 year	12-16 year	Adult
<60						160 (180)	160 (190)	170 (210)
60-79					150 (170)	150 (170)	150 (180)	160 (210)
80-99	100 (120)				140 (160)	150 (160)	150 (170)	150 (200)
100-119	100 (120)			(150)	130 (160)	140 (150)	150 (160)	150 (190)
120-139	100 (110)	110 (140)	110 (140)	120 (140)	130 (150)	140 (150)		150 (180)
140-159	90 (110)	100 (130)	110 (130)	110 (140)	120 (140)			(170)
160-179	100 (110)	100 (120)	100 (120)	100 (140)				
>180	90	90 (110)	100 (110)					

PR interval (ms) as Average (and Upper limit of Normal)

ECG Pédiatrique

- PR long
  - Myocardite
  - Epstein
  - Digitale
  - Hyperkaliémie

- PR court
  - WPW
  - Maladies métaboliques du glycogène

ECG pédiatrique normal
durée QRS

	0-1 month	1-6 month	6-12 month	1-3 year	3-8 year	8-12 year	12-16 year	Adult
QRS (ms)	50 (70)	50 (70)	50 (70)	60 (70)	70 (80)	70 (90)	70 (100)	80 (100)

QRS Duration (ms) as Average (and Upper limit of Normal)

ECG pédiatrique amplitude QRS

Voltage	Lead	0-1mo	1-6mo	6-12mo	1-3yr	3-8yr	8-12yr	12-16yr	Young
R	I	4 (8)	7 (13)	8 (16)	8 (16)	7 (15)	7 (15)	6 (13)	6 (13)
	II	6 (14)	13 (24)	13 (27)	13 (23)	13 (22)	14 (24)	14 (24)	9 (25)
	III	8 (16)	9 (20)	9 (20)	9 (20)	9 (20)	9 (24)	9 (24)	6 (22)
	aVR	3 (7)	3 (6)	3 (6)	2 (6)	2 (5)	2 (4)	2 (4)	1 (4)
	aVL	2 (7)	4 (8)	5 (10)	5 (10)	3 (10)	3 (10)	3 (12)	3 (9)
	aVF	7 (14)	10 (20)	10 (16)	8 (20)	10 (20)	10 (20)	11 (21)	5 (23)
	v4R	6 (12)	5 (10)	4 (8)	4 (8)	3 (8)	3 (7)	3 (7)	
	V1	15 (25)	11 (20)	10 (20)	9 (18)	7 (18)	6 (16)	5 (16)	3 (14)
	V2	21 (30)	21 (30)	19 (28)	16 (25)	13 (28)	10 (22)	9 (19)	6 (21)
	V5	12 (30)	17 (30)	18 (30)	19 (36)	21 (36)	22 (36)	18 (33)	12 (33)
	V6	6 (21)	10 (20)	13 (20)	12 (24)	14 (24)	14 (24)	14 (22)	10 (21)
S	I	5 (10)	4 (9)	4 (9)	3 (8)	2 (8)	2 (8)	2 (8)	1 (6)
	v4R	4 (9)	4 (12)	5 (12)	5 (12)	5 (14)	6 (20)	6 (20)	
	V1	10 (20)	7 (18)	8 (16)	13 (27)	14 (30)	16 (26)	15 (24)	10 (23)
	V2	20 (35)	16 (30)	17 (30)	21 (34)	23 (38)	23 (38)	23 (48)	14 (36)
	V5	9 (30)	9 (26)	8 (20)	6 (16)	5 (14)	5 (17)	5 (16)	
	V6	4 (12)	2 (7)	2 (6)	2 (6)	1 (5)	1 (4)	1 (5)	1 (13)

11 mm

20-25 mm

R and S Voltages: Mean (and Upper Limits of Normal)
According to Lead and Age

ECG pédiatrique
Morphologi QRS

- V1:
  - ***RSR' est aspect normal***
  - ***Mais si R' > R : anormal***
  - ***Onde R unique anormal > 6 mois***
  - ***Onde T + 1e semaine, après anormal T- V1***

- HVG:
  - N'utiliser que V6 (20 mm)
    - Si V6 croise V5 = anormal

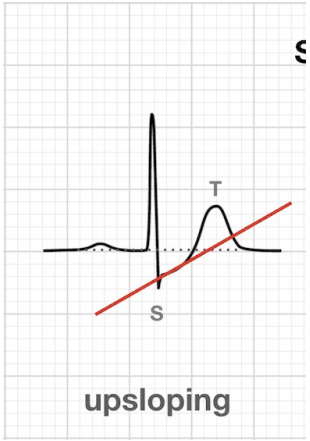
ECG pédiatrique
QRS

- Ondes Q
  - Normal
    - Max 0.3 ms
    - < 5 mm
    - Jusque 8 mm en DIII
  - Anormal
    - V1
    - Trop large et trop profond

ECG pédiatrique
ST

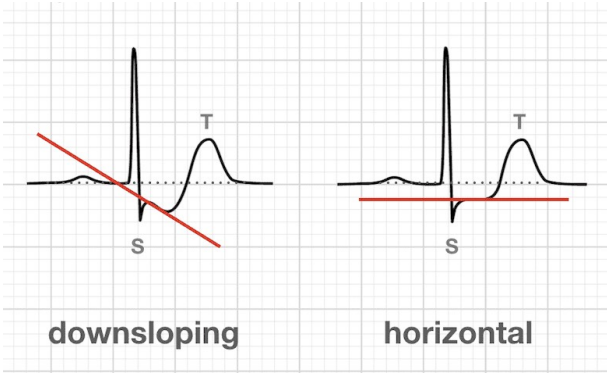
Normal

Dépression ST 1 mm (2 mm precordial) = normal
Point J peut etre déprimé avec ST ascendant
Repolarisation précoce normal adolescents.



Anormal

depression descendante avec T-
depression horizontale > 80 ms



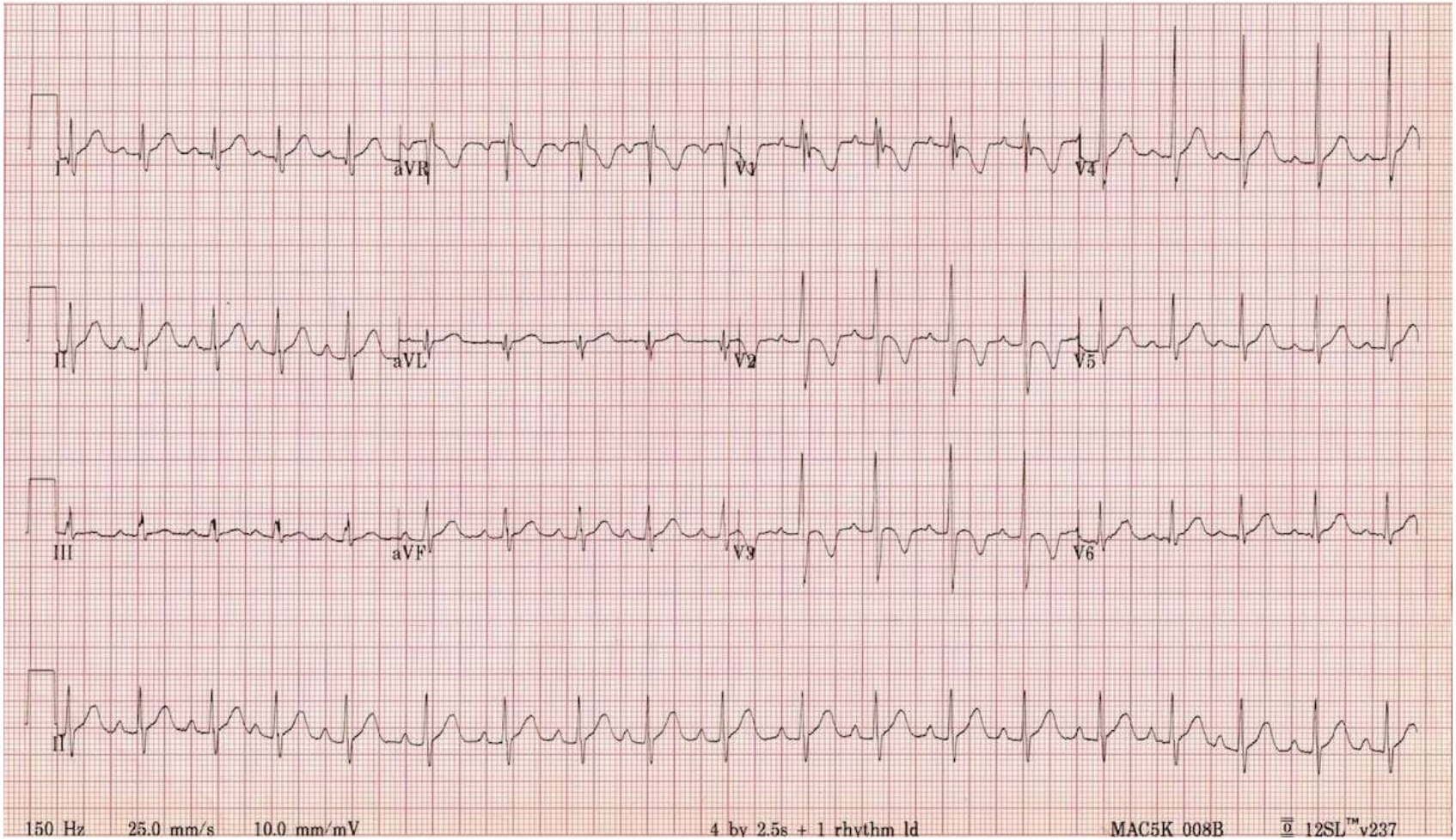
ECG pédiatriqu

- QTc
  - <6 mois: < 490 ms
  - Au delas 450 ms

ECG pédiatrique
ondes T

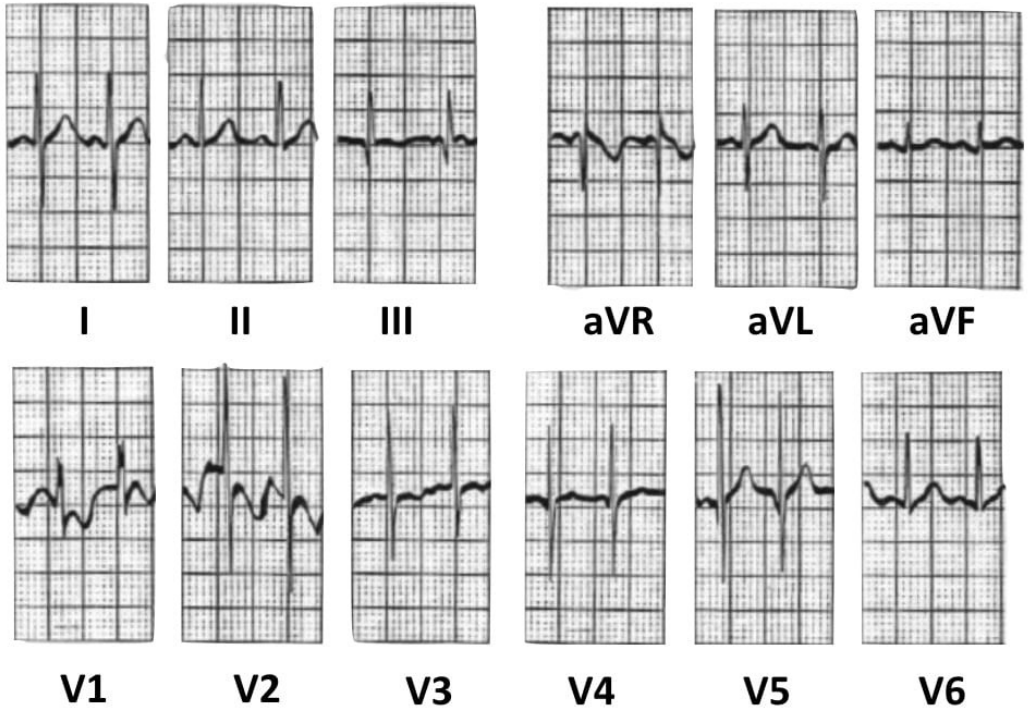
- < 1 semaine
  - T+ précodrial
- >1 semaine – 8 ans
  - T- V1-V3 normal
- > 8 ans
  - T- au dela de V1 anormal

ECG normal
2 ans



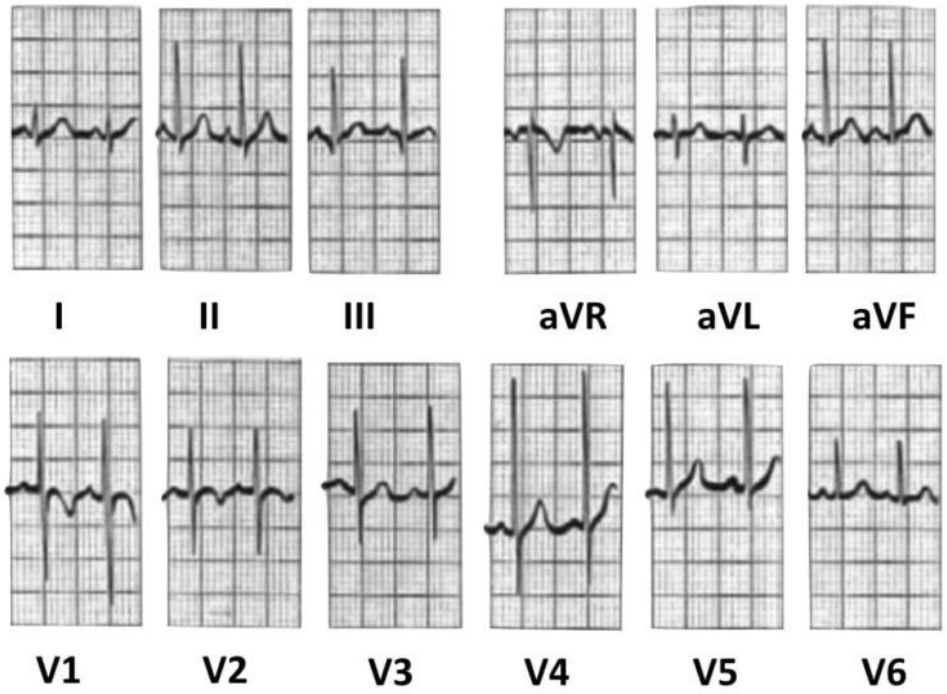
ECG normal

Normal ECG: Age 1 year



ECG normal

Normal ECG: Age 2 year



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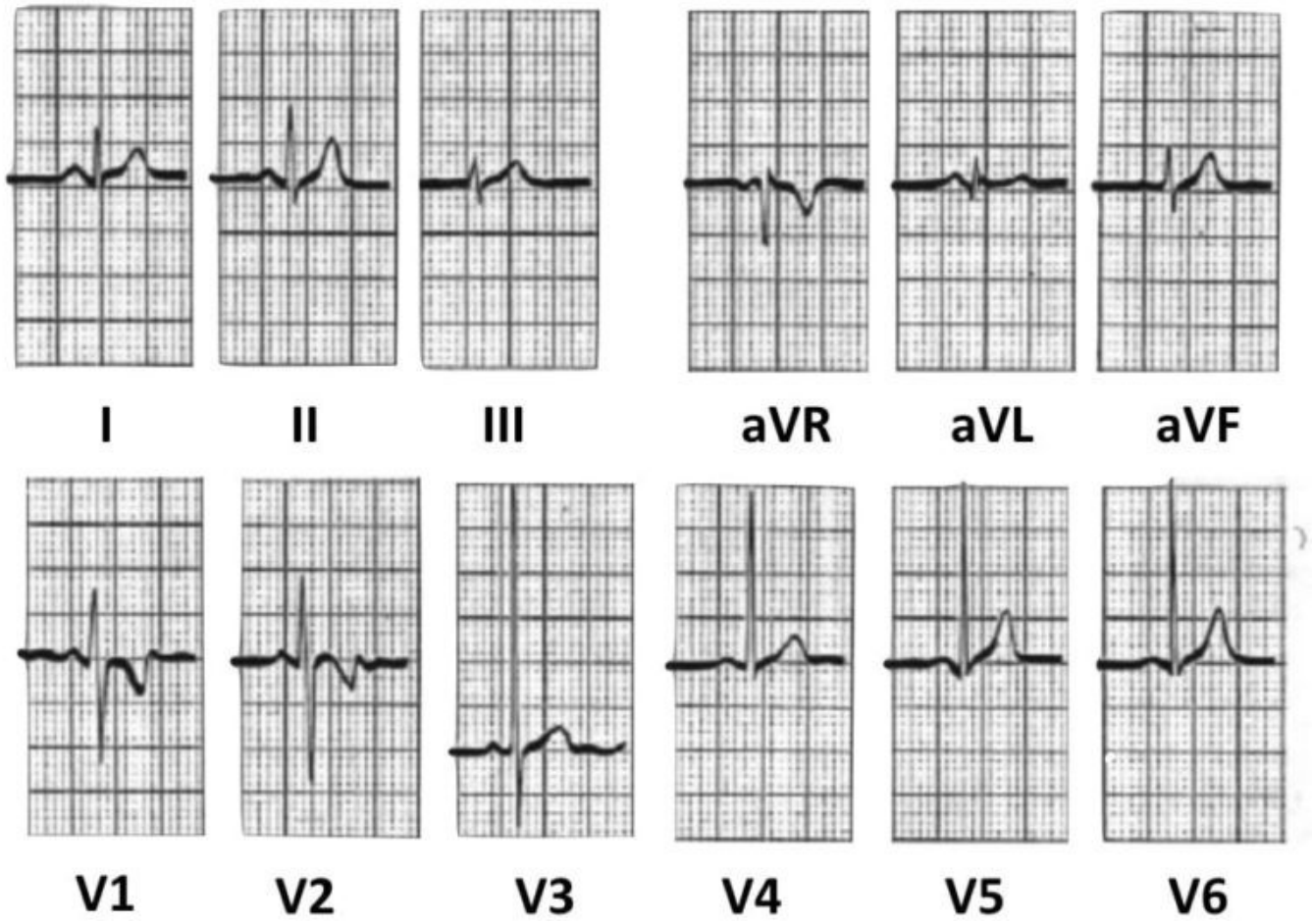
Normal ECG: Age 5 years



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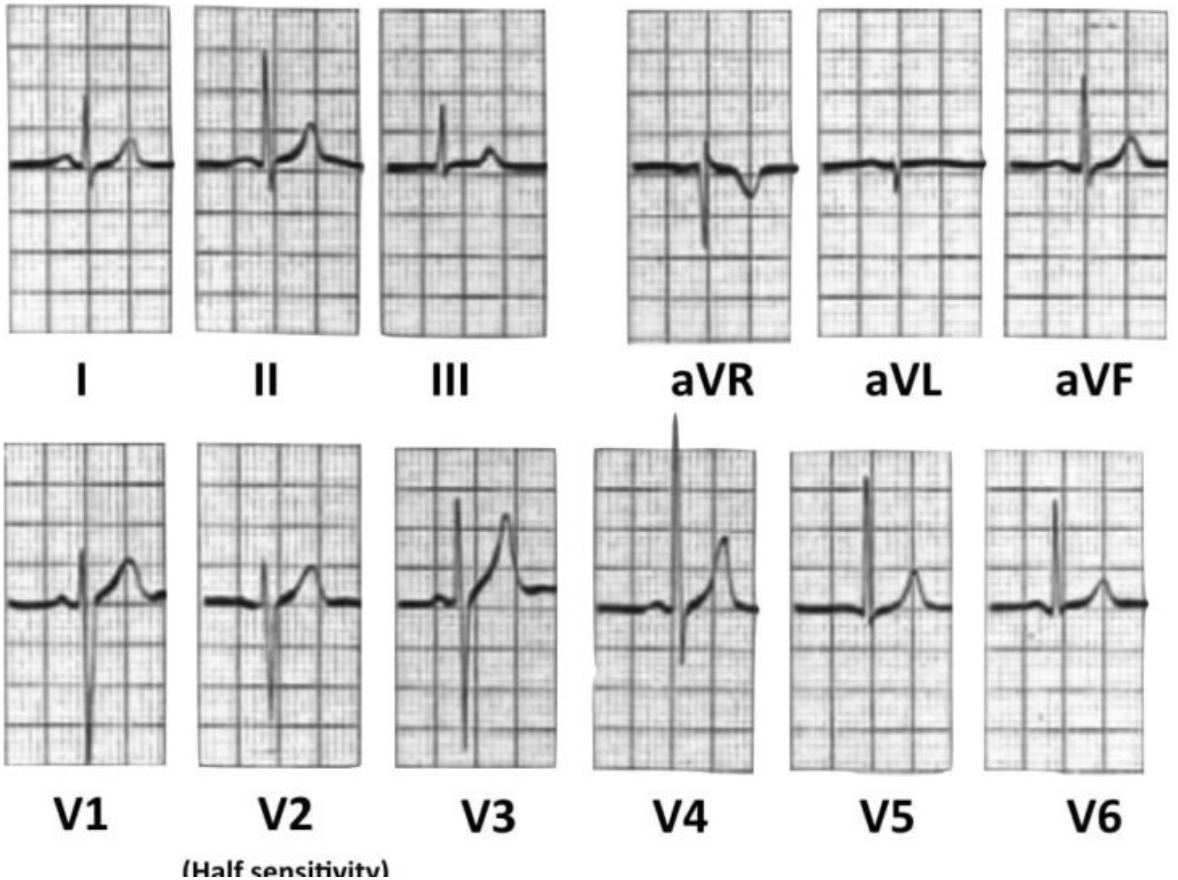
Normal ECG: Age 10 years



ECG SPORTIFS

Athlète

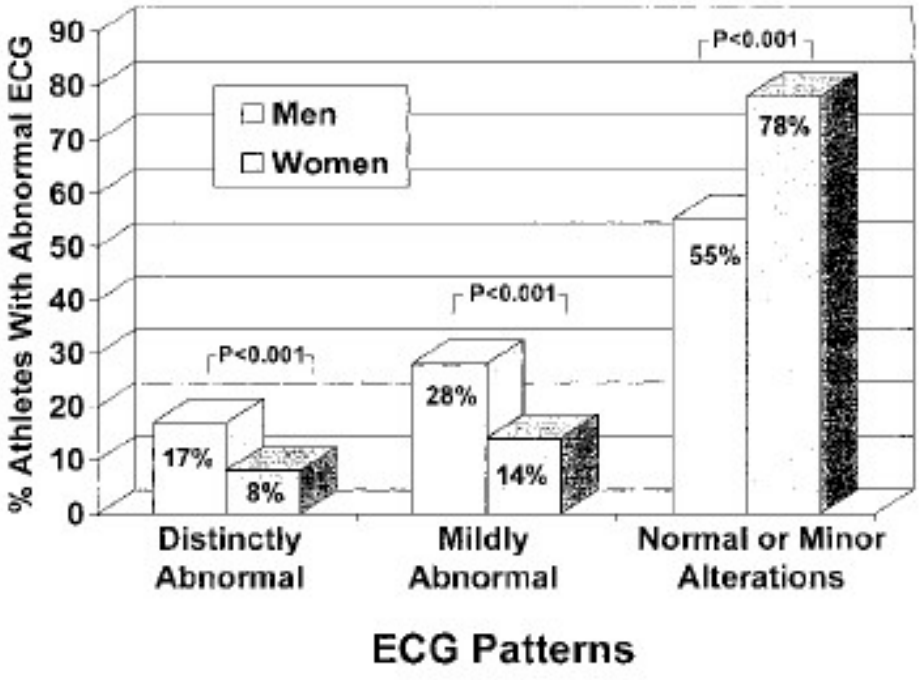
- ESC:
  an individual of young or adult age, either **amateur or professional**, who is engaged in **regular exercise training** and participates in official sports **competition**

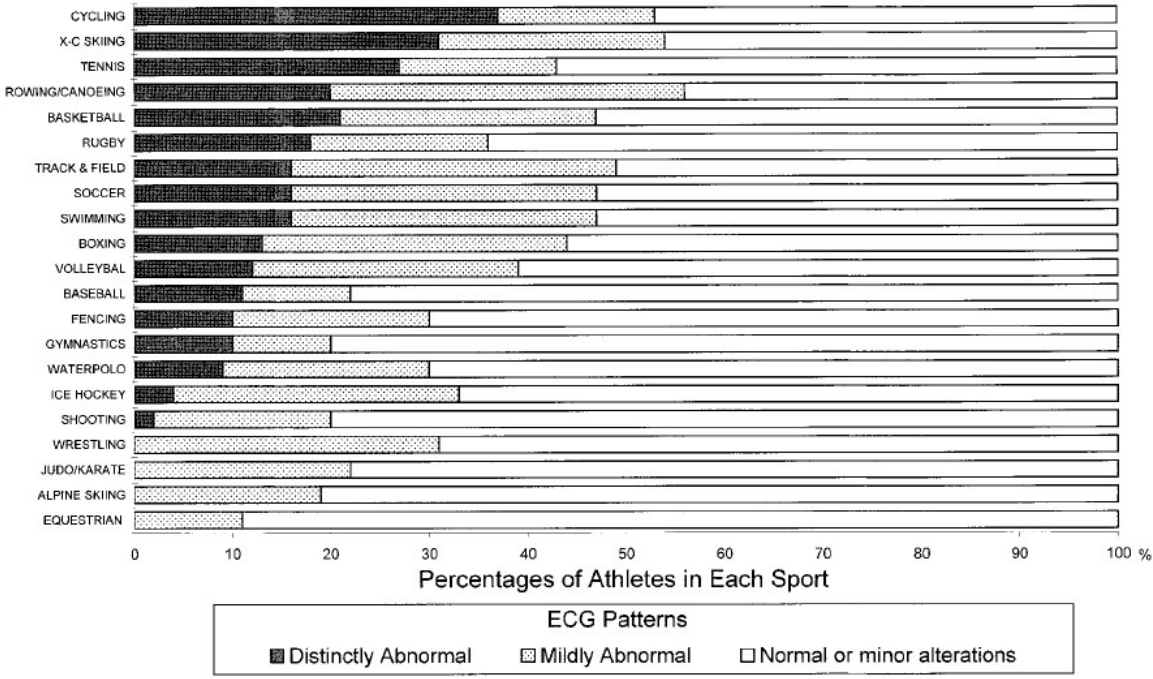
- AHA:
  competitive athlete as an individual involved in regular (usually intense) training in **organized individual or team sports**, with an emphasis on **competition and performance**

Types of athletes

- Recreational:
  - Sport for pleasure and leisure-time
  - Exercise > 4 h/week
- Competitive
  - Highly trained, greater emphasis on performance and winning
  - Exercise > 6 h /week
- Elite
  - Exercise > 10 h / week

ECG findings in athletes
LVH

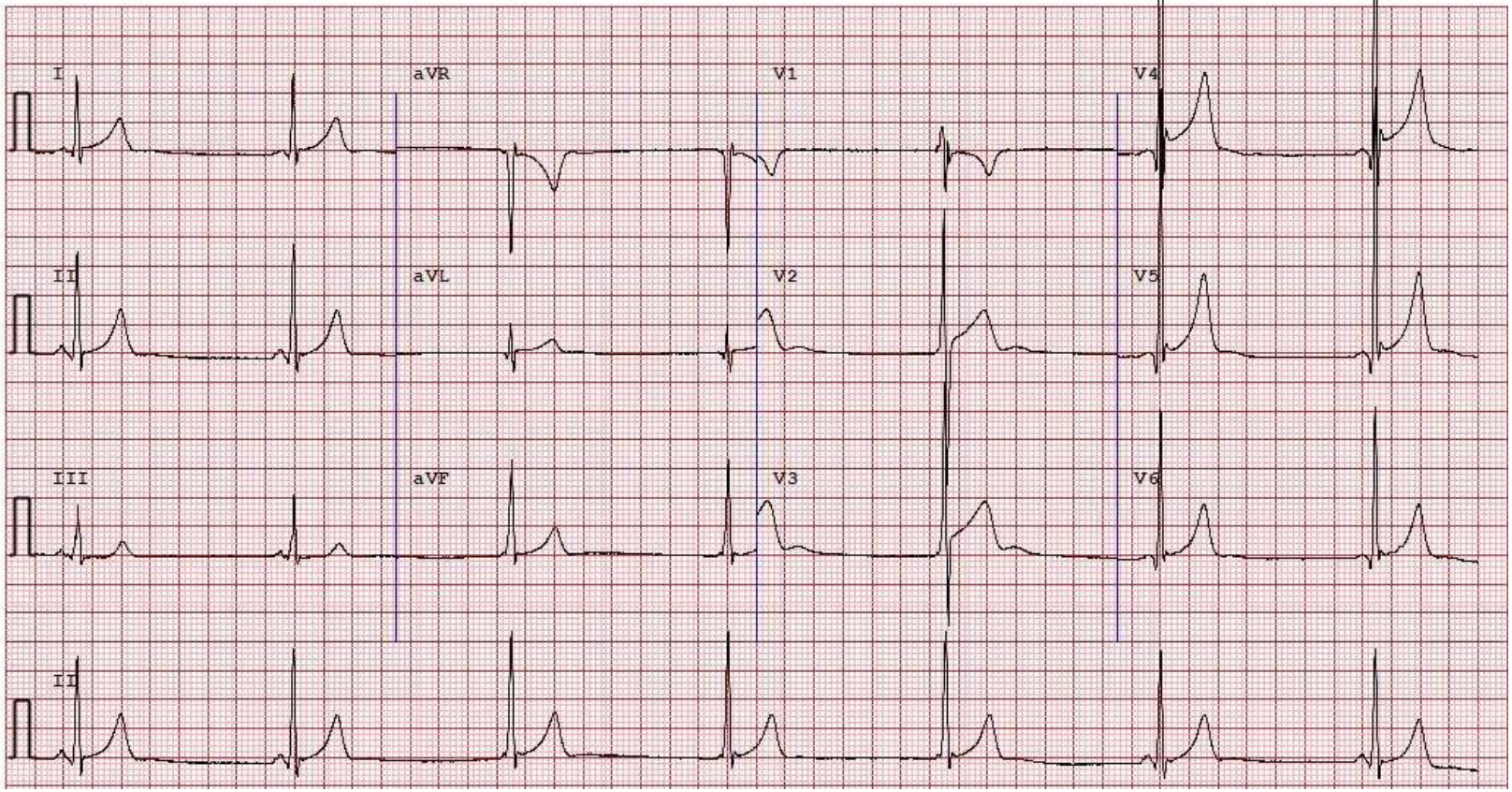




***Pellica Circulation*. 2000;102:278-284.)**

Normal ECG in athlete

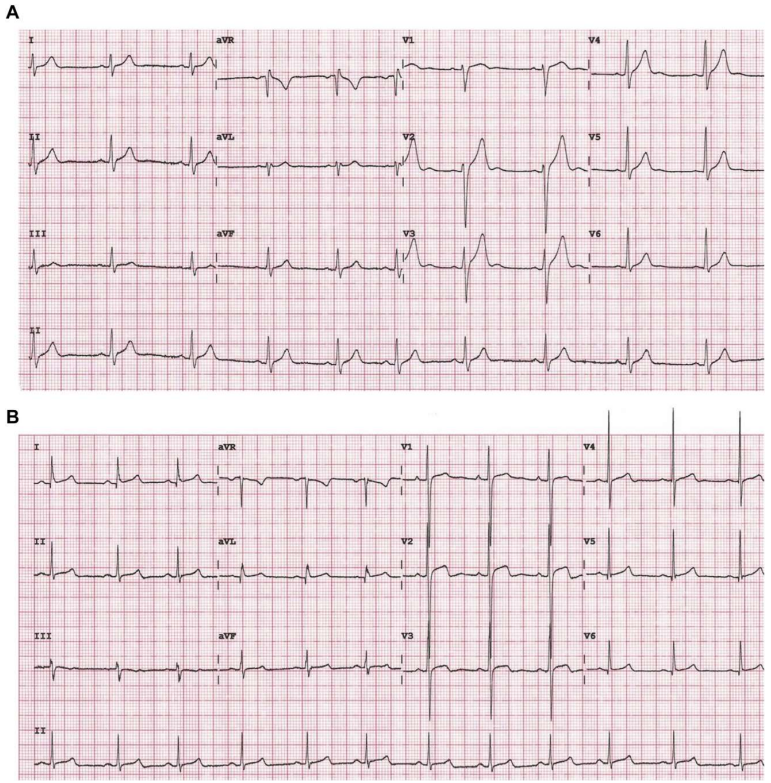
Figure 2: Several normal features of an athlete ECG are seen here. There is sinus bradycardia at about 40 beats/min, sinus arrhythmia, junctional escape rhythm (seen in beats 3-5), and exceedingly large QRS voltage (especially in V4-V5).



Normal ECG
early repolarisation

White athlete

Black athlete



B. Gerber UCL Brussels

ECG anomalities in athletes
Normal findings in athletes

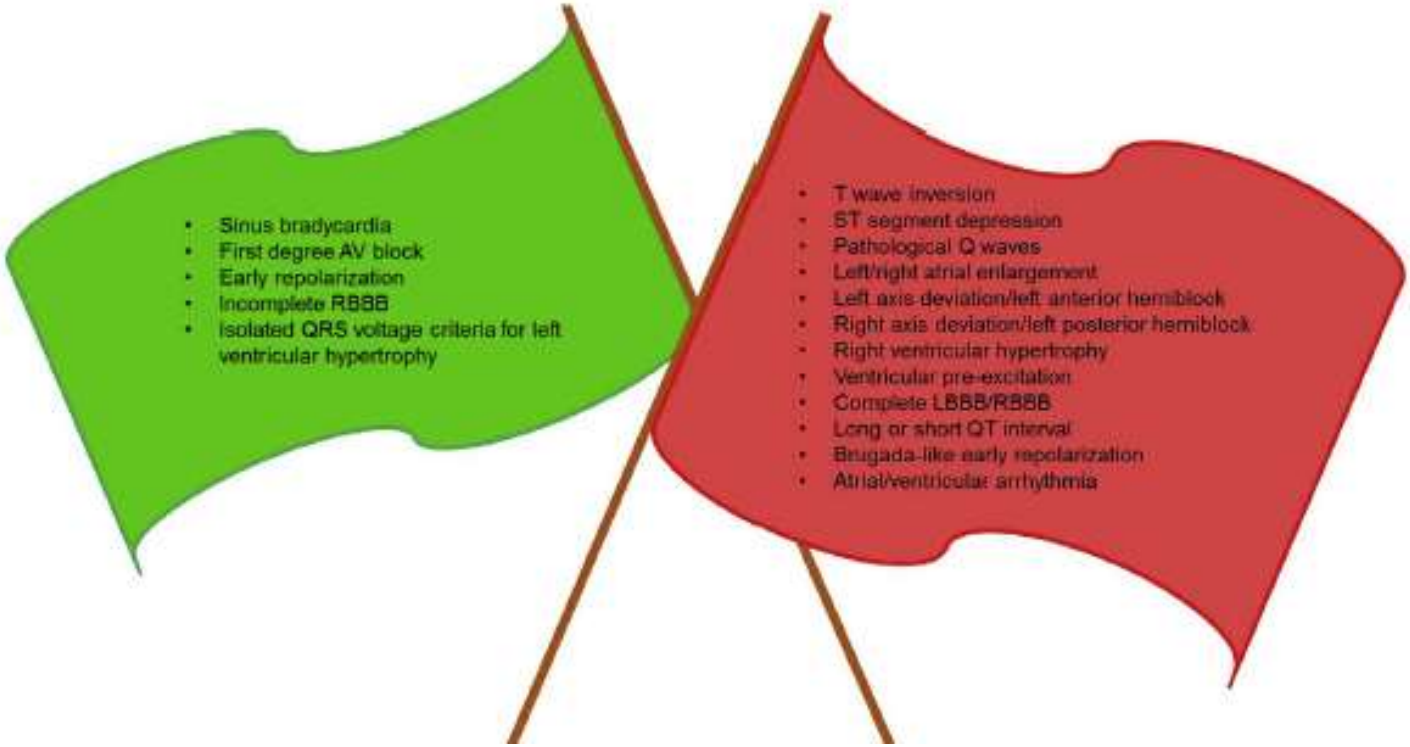
Box 1 Normal ECG findings in athletes

1. Sinus bradycardia (≥ 30 bpm)
2. Sinus arrhythmia
3. Ectopic atrial rhythm
4. Junctional escape rhythm
5. 1° AV block (PR interval > 200 ms)
6. Mobitz Type I (Wenckebach) 2° AV block
7. Incomplete RBBB
8. Isolated QRS voltage criteria for LVH
   - *Except*: QRS voltage criteria for LVH occurring with any non-voltage criteria for LVH such as left atrial enlargement, left axis deviation, ST segment depression, T-wave inversion or pathological Q waves
9. Early repolarisation (ST elevation, J-point elevation, J-waves or terminal QRS slurring)
10. Convex ('domed') ST segment elevation combined with T-wave inversion in leads V1–V4 in black/African athletes

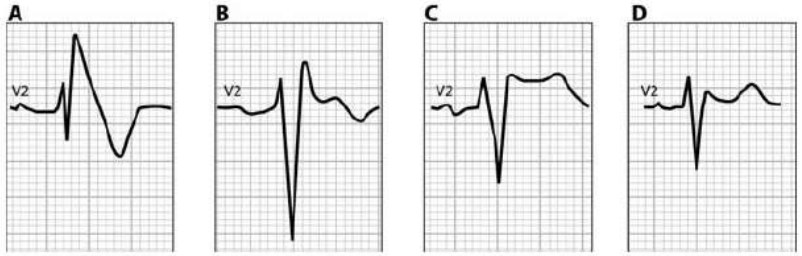
These common training-related ECG alterations are physiological adaptations to regular exercise, considered normal variants in athletes and do not require further evaluation in asymptomatic athletes.

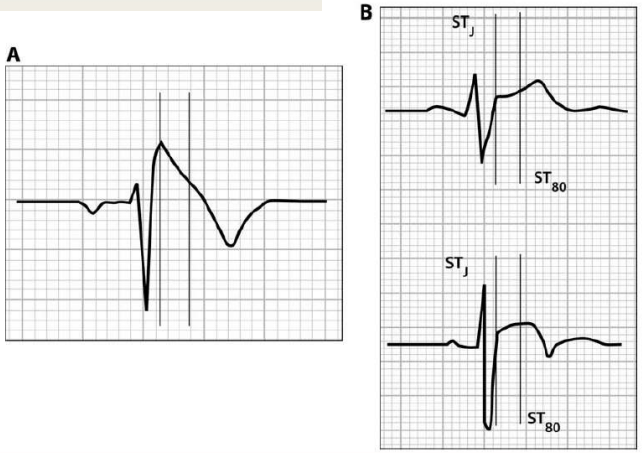
Drezner JA, et al. Br J Sports Med 2013;47:122–124.

ECG in athletes
green and red flags



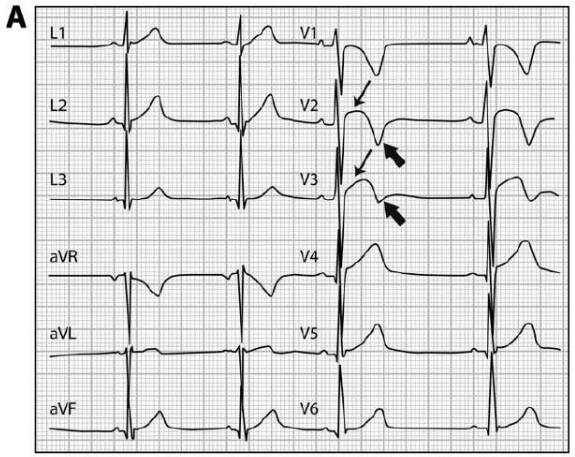
Anormal ECG
Early afterdepolarization vs Brugada

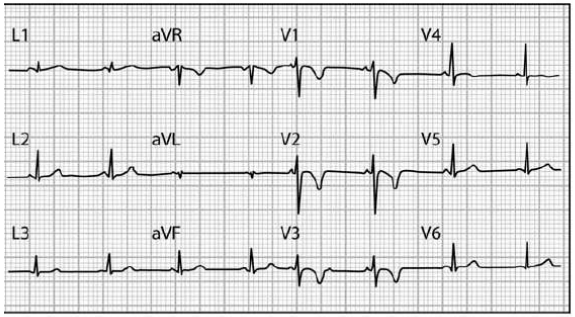




Corrado Eur. Heart J. (2010) 31, 243–259

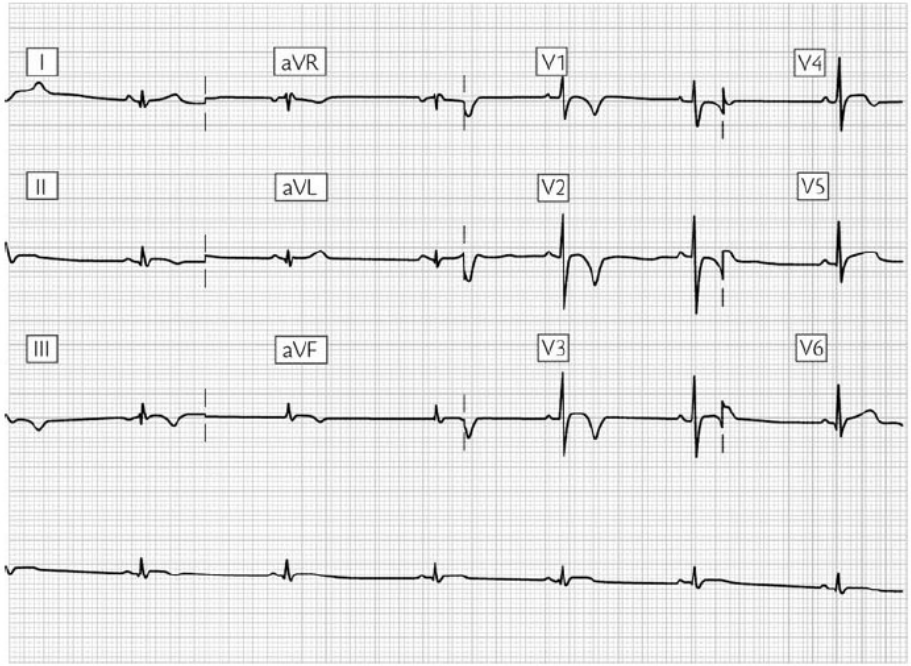
Early repolarization vs ARVD/C





Corrado Eur. Heart J. (2010) 31, 243–259

Abnormal ECG
ARVD/C



Corrado Eur. Heart J. (2010) 31, 243–259

Anormal ECG
HCM

Corrado Eur. Heart J. (2010) 31, 243–259

Normal ECG in african athlete

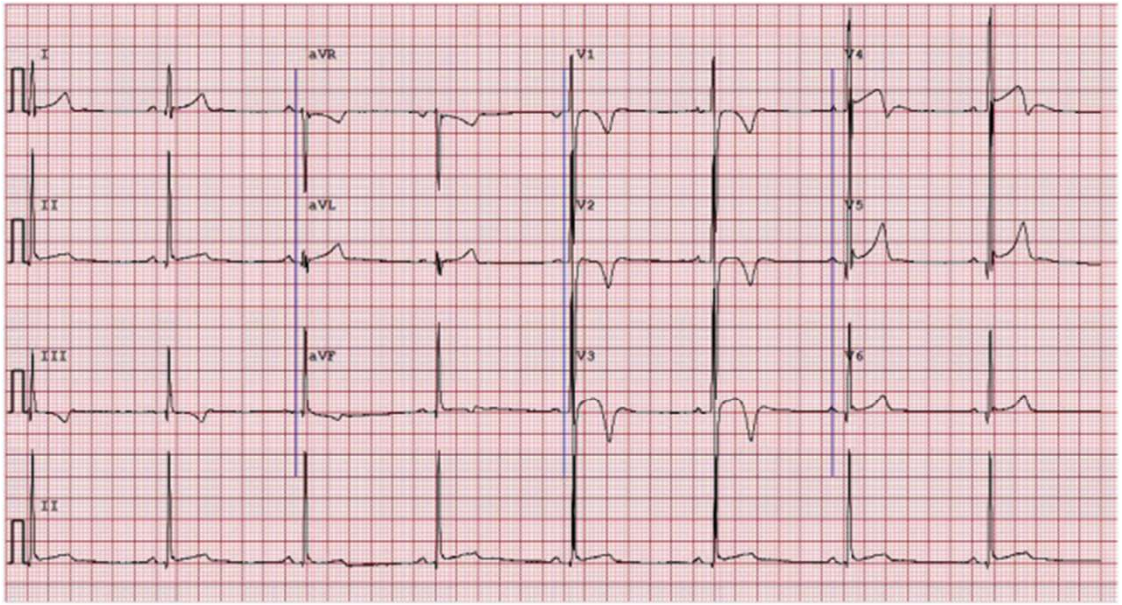


Figure 3: Normal ECG in an African-American athlete. The ST segment/T wave pattern in V2-V4 is a normal variant and does not require further evaluation. While the T wave inversion in aVF is borderline abnormal, two contiguous lead are required excluding lead III, and inferior T wave inversions may occasionally be seen in African-American athletes.

ECG abnormalities in athletes
ESC and Seattle criteria

	ESC 2010	Seattle Criteria	Refined criteria
T wave inversion	>2 mm in > 2 adjacent leads	**>V2 (white athletes)** **>V4 (black athletes)**	>V1 (white athletes) >V4 (black athletes)
ST depression	>0.5 mm in >2 leads	As ESC	As ESC
Q waves	> 4mm in any lead (except DIII and aVR)	>3 mm in >2 leads (except DIII and vR)	As ESC
Long QT	>440 ms (male) >460 ms (female)	>470 ms (male) >480 ms (female)	>470 ms (male) >480 ms (female)
Short QT	< 380 ms	<320 ms	<320 ms
RVH	R-V1+S-V5>10.5 mm	R-V1+S-V5>10.5 mm and axis>120^0	As ESC
QRS axis	<-30^0 or >+120^0	<-30^0	<-30^0 or >+120^0
Left or right atrial enlargement	- Part of P >0.1 mV and >40 ms V1 P wave > 2.5 mm DII	P >120 ms DI or DII and - Part of P >0.1 mV and >40 ms V1	As ESC
RBB	RsR'V1 and QRS > 120 ms	Not relevant	As ESC
LBB	QRS >120 ms and – V1	As ESC	As ESC
IV delay	>120 ms	>140 ms	As ESC
WPW	PR <120 ms with or wo δ w.	PR <120 ms with δ w.	PR <120 ms with δ w.
Brugada pattern	+	As ESC	As ESC
Atrial arrhythmia	SVT, AF, flutter	As ESC	As ESC
Ventricular arrhythmia	> 2 / 10 s Couplets, triplets, NSVT	As ESC	As ESC

ECG screening in athletes