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SKRIPT

2. STAATSEXAMEN

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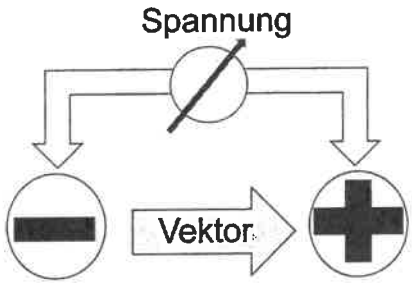
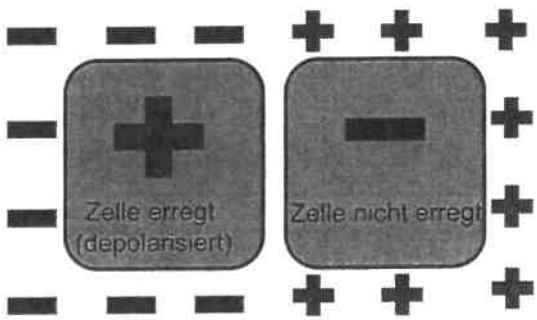
Inhaltsverzeichnis

Entstehung des EKG

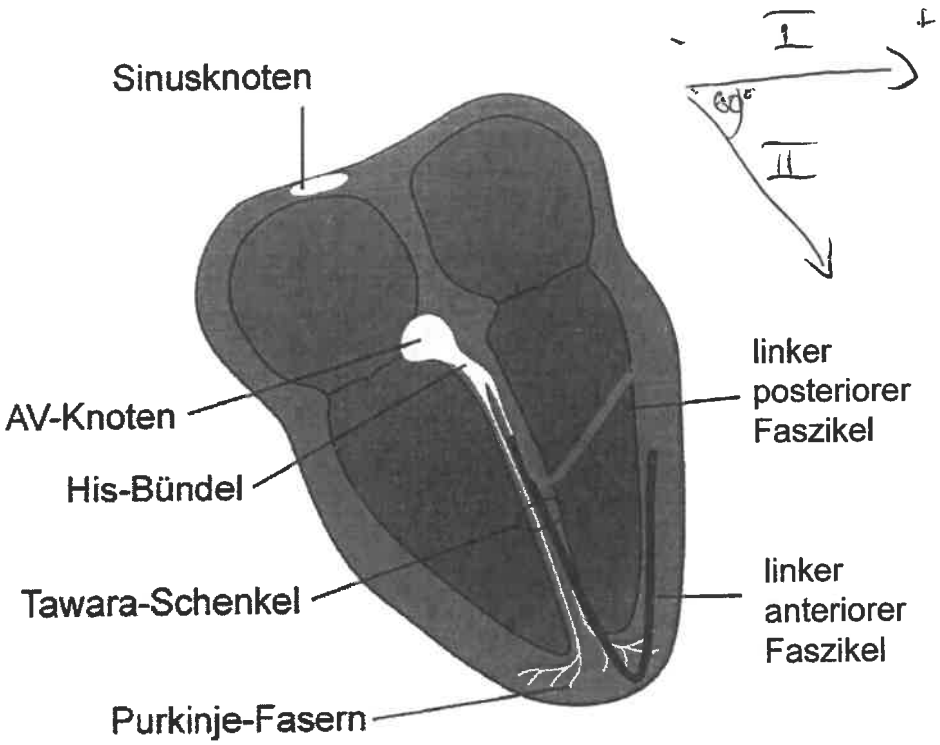


Vektor: Ausdruck des Spannungs- bzw. Ladungsunterschieds im Raum



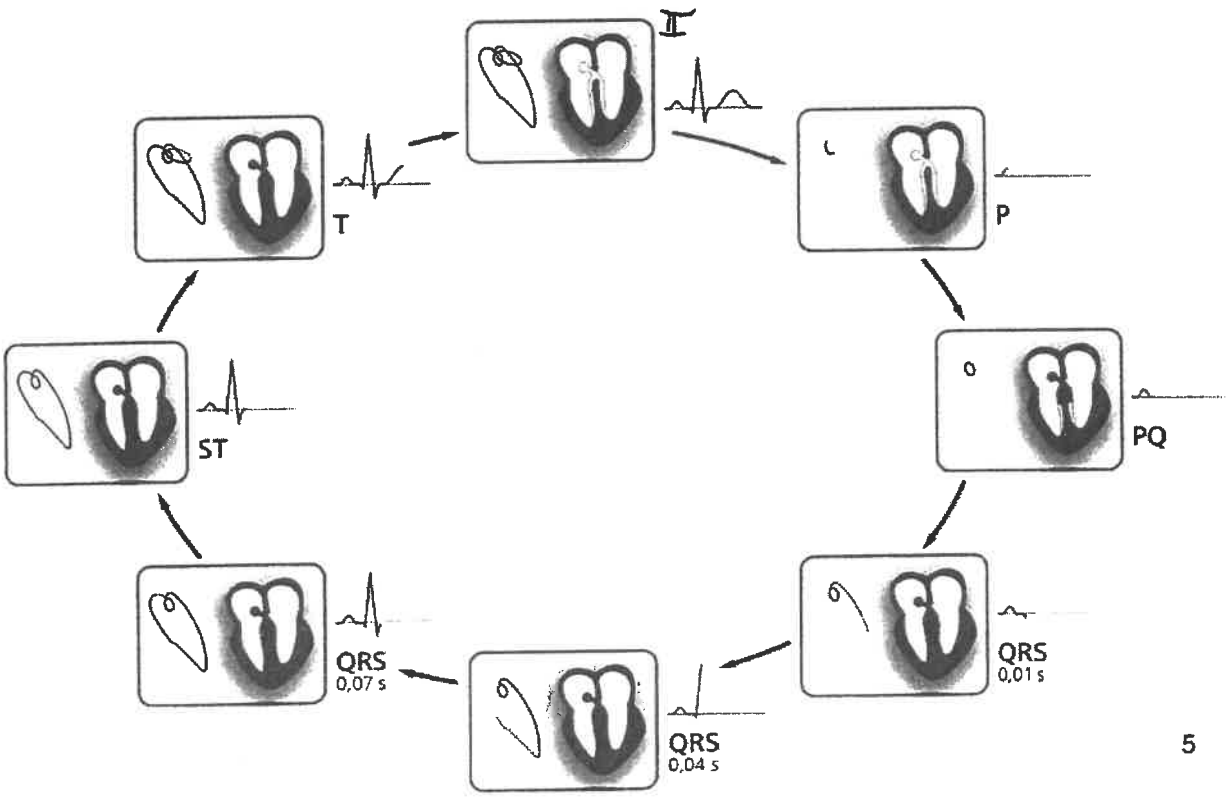
1.) Ein Vektor zeigt von erregtem (-) auf unerregtes Gewebe (+).
2.) Das Oberflächen-EKG entsteht durch Summation aller (Einzel-)Vektoren.
3.) Der Summationsvektor wird zu jedem Zeitpunkt auf 12 definierte Ableitungen projizie

Erregungsleitungssystem



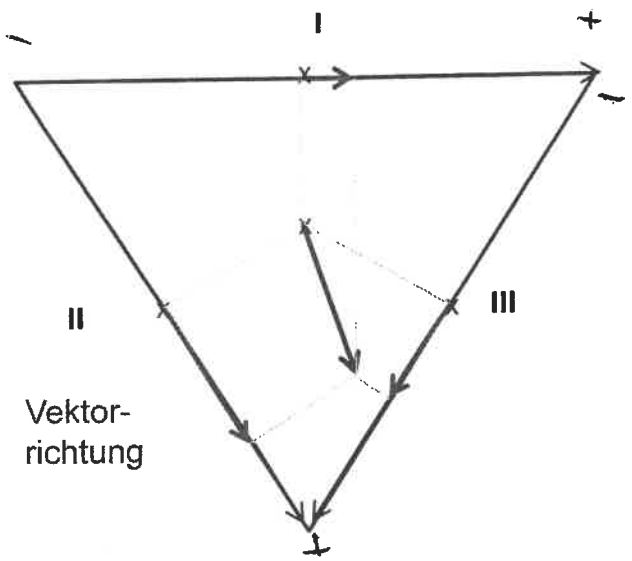
Aus: ML Physiologie-Skript

Vektorverlauf während einer Herzerregung

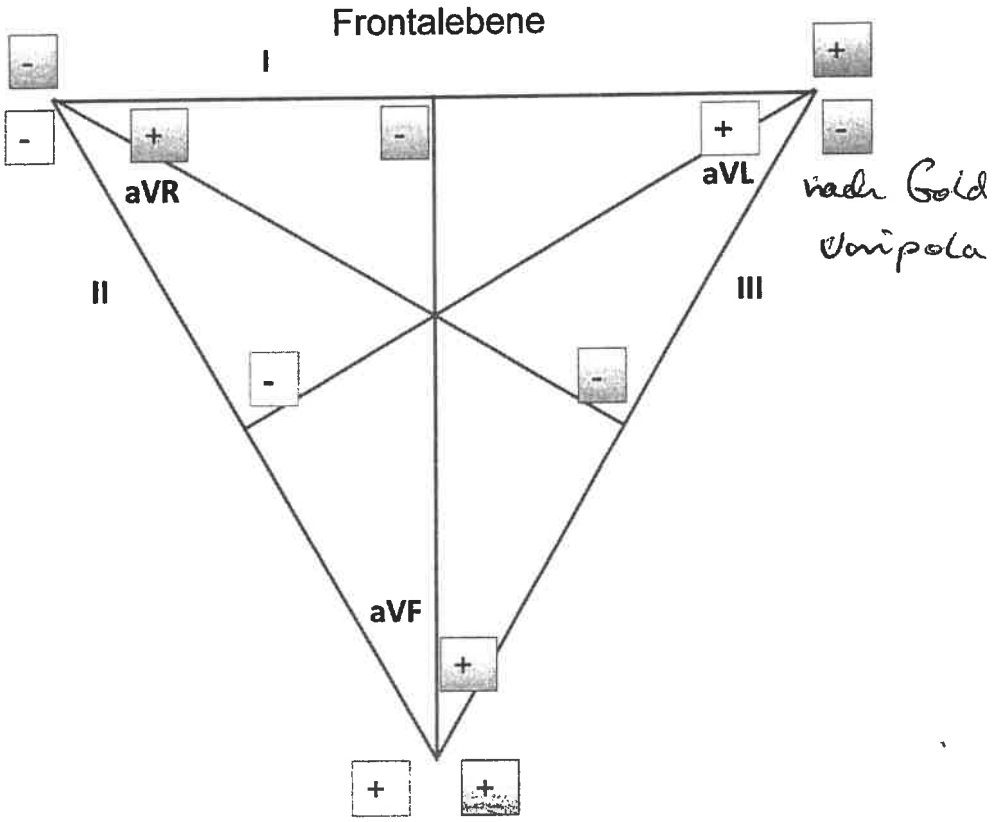


Wie projiziert man einen Vektor auf eine Ableitung?

nach Eindhoven = bipolar



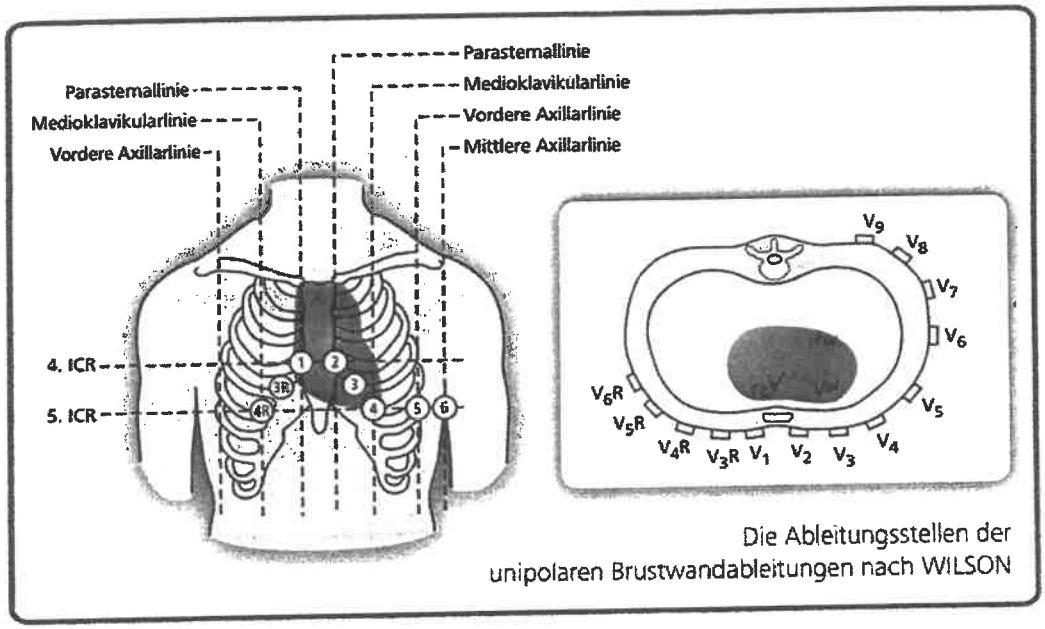
Wie verlaufen die Ableitungen? Extremitätenableitungen



Wie verlaufen die Ableitungen?
Brustwandableitungen

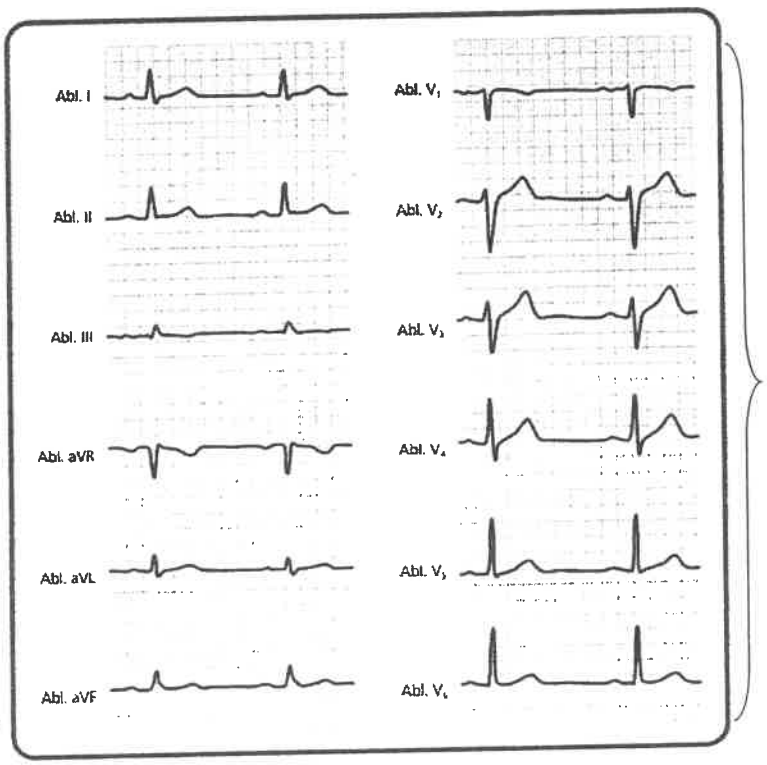
Transversalebene

nach Wilson



Die Ableitungsstellen der unipolaren Brustwandableitungen nach WILSON

12-Kanal-EKG

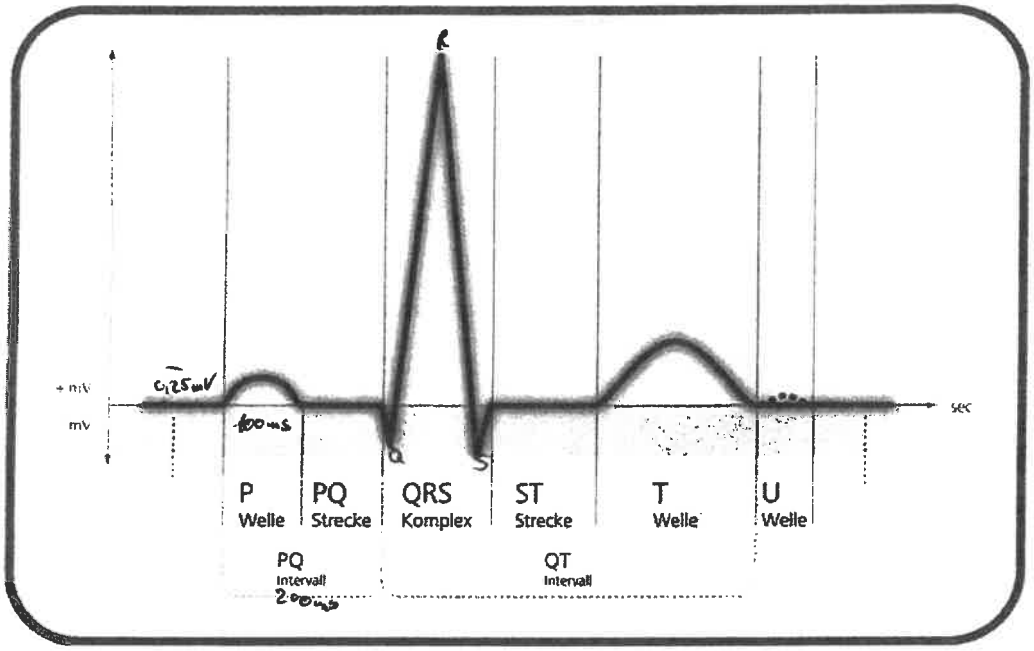


Einthofen-Ableitungen (bipolar)

Goldberger-Ableitungen (unipolar)

Brustwand-Ableitungen nach Wilson (unipolar)

Nomenklatur



R-Zacke: positiv **Q- und S-Zacken:** negativ

Q-Zacke: vor R-Zacke

S-Zacke: nach R-Zacke

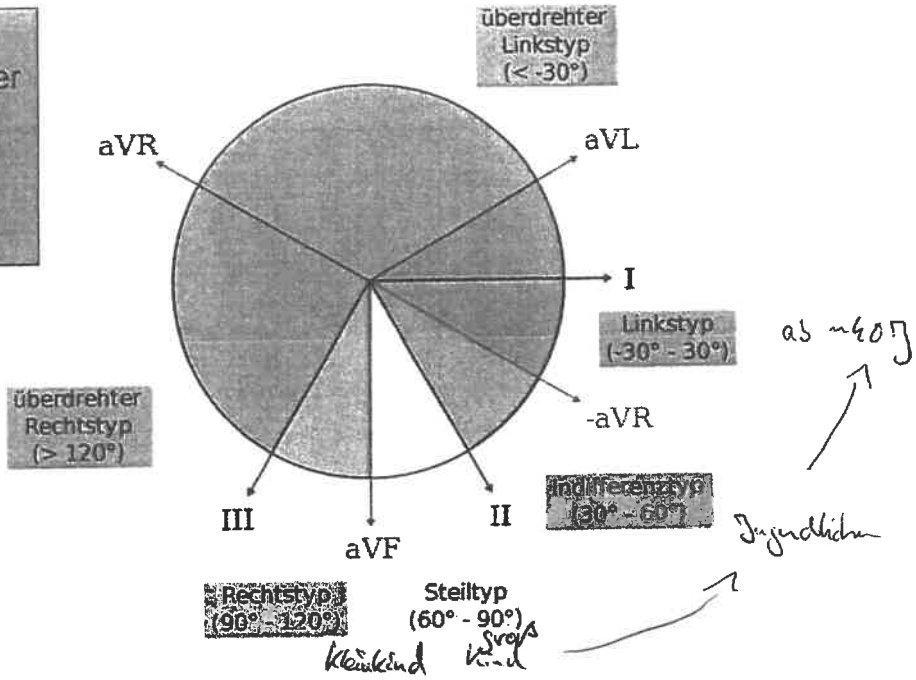
EKG-Befundung

1. **Lagetyp**
2. Rhythmus und Frequenz
3. Erregungsausbreitung
   a) P-Welle
   b) PQ-Zeit
   c) QRS-Breite
   d) R/S-Umschlag, R und S in den Brustwandableitungen
   e) Q-Zacken
4. Erregungsrückbildung
   a) ST-Strecke
   b) T-Welle
   c) QT-Zeit

Lagetypen – Cabrera Kreis

Lagetyp:
Lage des Hauptvektors der intraventrikulären Erregungsausbreitung in Projektion auf die Frontalebene

→ QRS-Hauptvektor in der Frontalebene



Lagetypenwechsel: z.B. bei Lungenembolie oder Asthma bronchiale-Anfall (z.B. von IT zu ST). Drehung in Sagittalebene: R und S sind in allen Ableitungen gleich groß

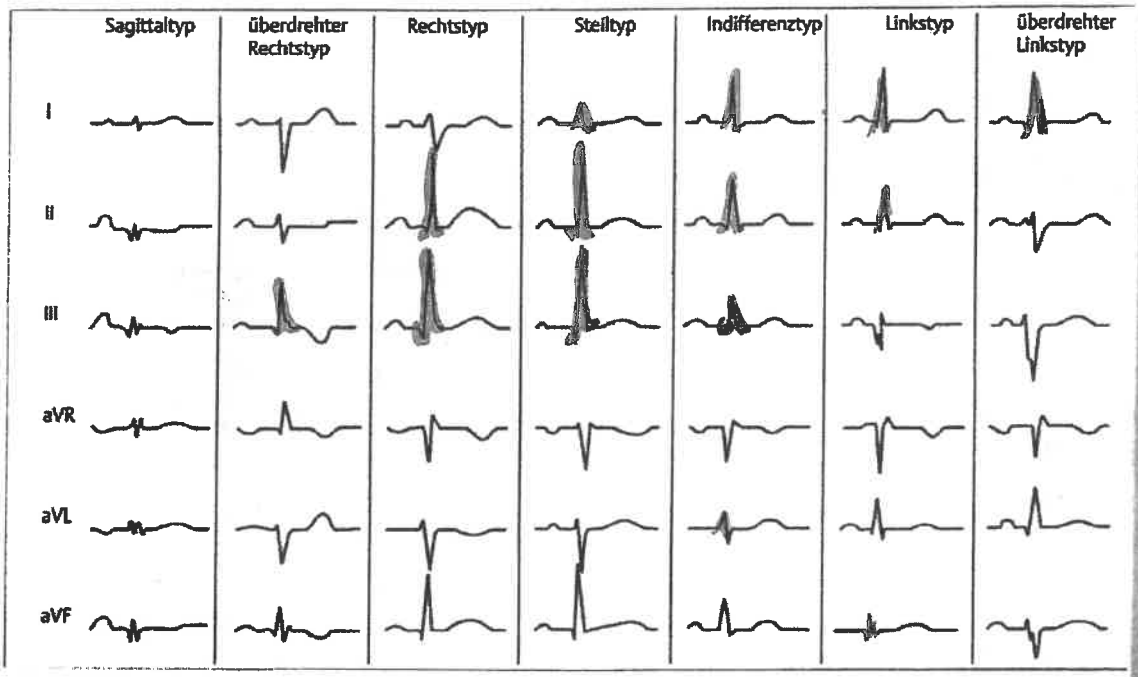
Lagetypbestimmung

QRS in Ableitungen I, II und III: Fläche positiv oder negativ?

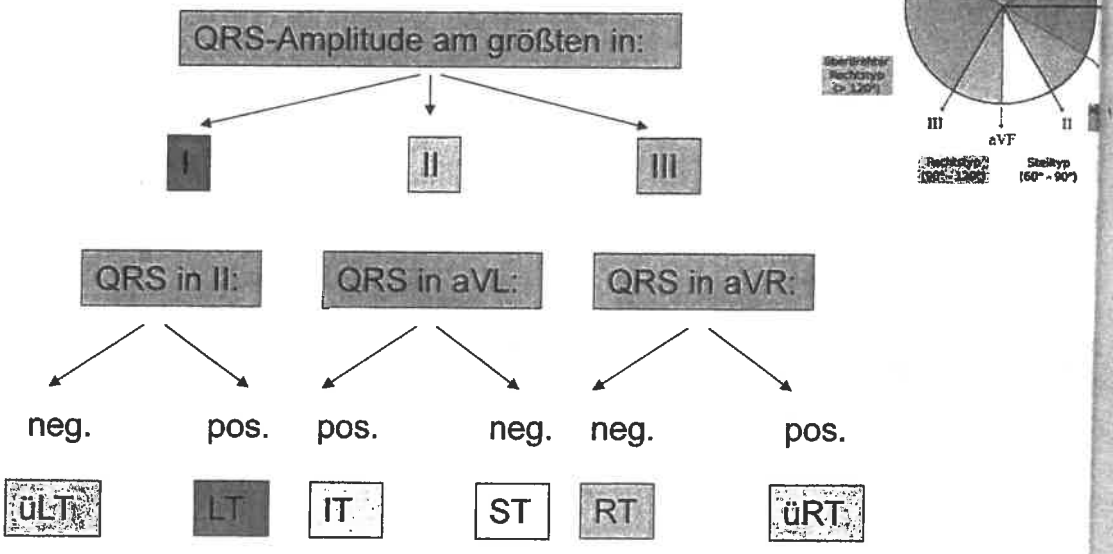
2. Einordnung nach Tabelle

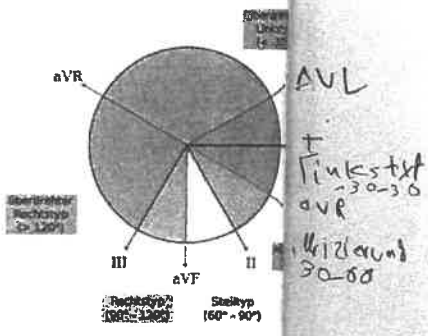
Abltg. I	Abltg. II	Abltg. III	Lagetyp	
+	-	-	Überdr. Linkstyp	
+	+	-	Linkstyp	
+ +	+ + +	+	Indifferenztyp	aVL +
+	+ + +	+ +	Steiltyp	aVL -
-	+	+	Rechtstyp	
-	-	+	Überdrehter Rechtstyp	
+/-	+/-	+/-	Sagittaltyp	

Lagetypen



Lagetypbestimmung





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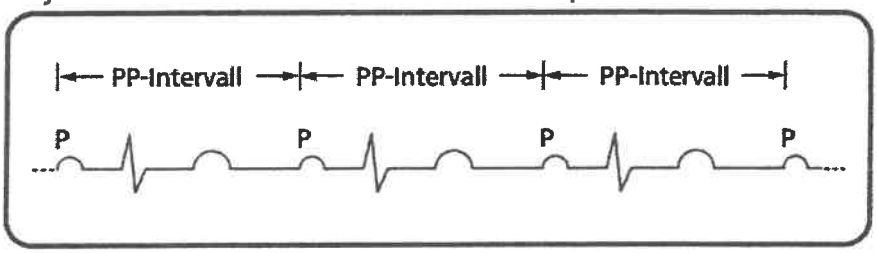
4. Erregungsrückbildung
   a) ST-Strecke
   b) T-Welle
   c) QT-Zeit

2. Rhythmus ...

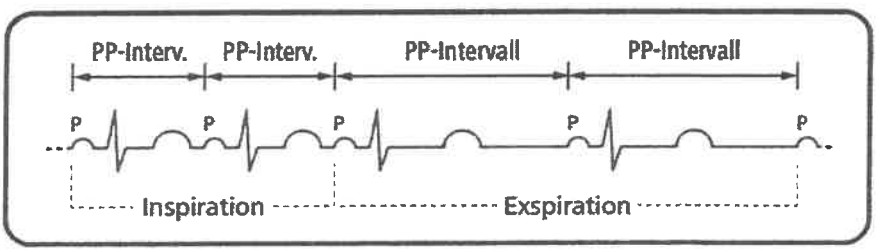
Sinusrhythmus (SR): Nach jeder P-Welle kommt ein QRS-Komplex.



Charakterisierung des Sinusrhythmus:
Reguläre P-Wellen, konstante PP-Intervalle, konstante Relation P-Welle: QRS-Komplex

Sinusarrhythmie: ... aber die P-Wellen sind nicht regelmäßig.

Respiratorische Arrhythmie:
Frequenz
↑ bei Inspiration
↓ bei Exspiration



Weitere Grundrhythmen:
Vorhofflimmern/ -flattern, Re-Entry-Tachykardien, SR mit Ersatzrhythmus bei Block, Ventrikuläre Tachykardie (VT), Kammerflimmern (VF), Asystolie

... und Frequenz

Norm: 60 bis 100/min

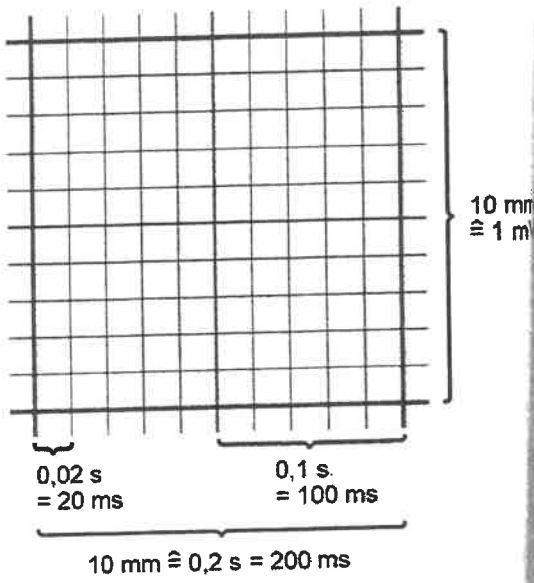
Sinusbradykardie: < 60/min
Sinustachykardie: > 100/min

Methoden zur Frequenzbestimmung

1. EKG-Lineal

1. (R-Zacken auf 6 Sekunden + 1) * 10

2. CAVE: Vorhof- und Kammerfrequenz unterscheiden!



Papiervorschub 50 mm/s

Quelle: Medilearn Physiologie 6

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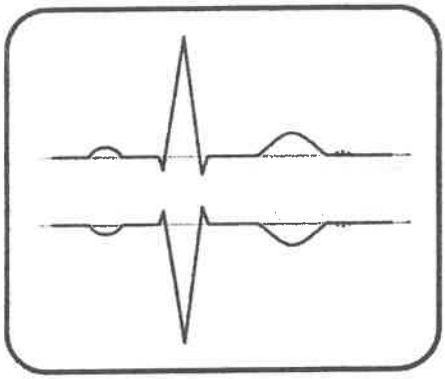
3. Erregungsausbreitung – P-Welle

P-Welle - Normalbefund

Positiv? Negativ erlaubt:
- in V1
- bei neg. QRS in Extremitäten („konkordant neg. P“)

Form? Normal:
- Dauer 0,05 - 0,1 s
- gleichmäßige Wölbung
- Amplitude bis 0,25 mV

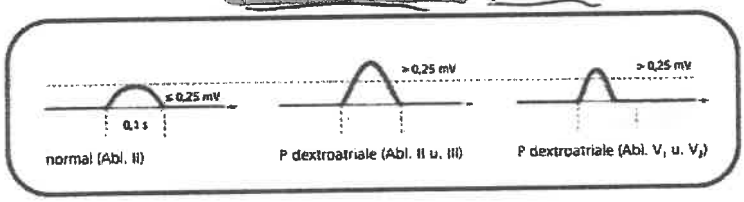


P-Welle – pathologische Befunde

P dextroatriale/ pulmonale

P > 0,25 mV in II, III

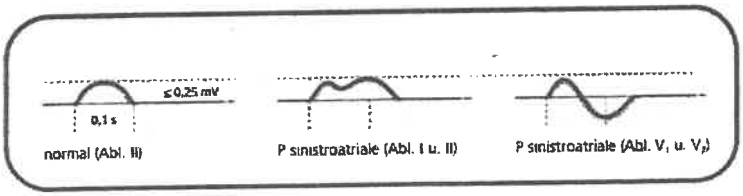
Genese: Druck- oder Volumenbelastung des rechten Vorhofs (z.B. LAE)



P sinistroatriale/ mitrale

P > 0,1 s
P doppelgipflig in I, II
bzw. biphasisch in V1, V2

Genese: Druck- oder Volumenbelastung des linken Vorhofs



P biatriale

P > 0,25 mV + P > 0,1s

Genese: Druck- oder Volumenbelastung beider Vorhöfe

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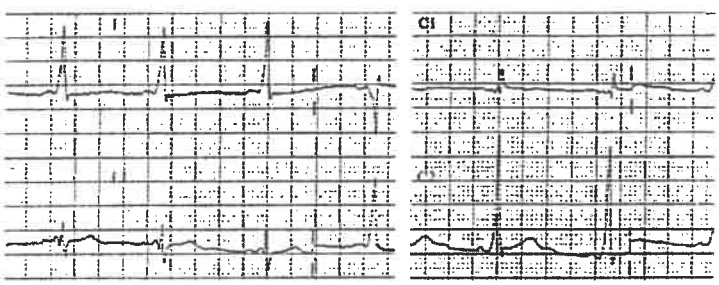
3. Erregungsausbreitung – PQ-Zeit

PQ-Zeit:

Beginn P-Welle bis Beginn Q-Zacke
Norm: 0,12 – 0,20 s

PQ-Zeit-Verkürzung

Wolff-Parkinson-White (WPW)-Syndrom
Präexzitation durch akzessorisches Kent-Bündel (atrio-ventrikuläre Leitungsbahn)
→ Delta-Welle (v.a. bei Bradykardie)

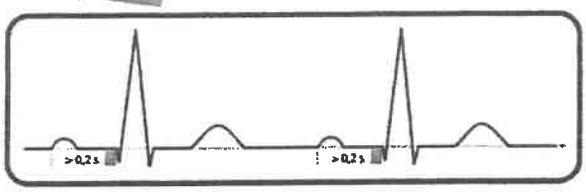


http://de.wikipedia.org/w/index.php?title=Datei:Wolff-Parkinson-White_syndrome_12_lead_EKG.png&filetimestamp=20060511114938

Lown-Ganong-Levine (LGL)-Syndrom
Präexzitation durch akzessorisches James-Bündel (atrio-noduläre Leitungsbahn), keine Delta-Welle

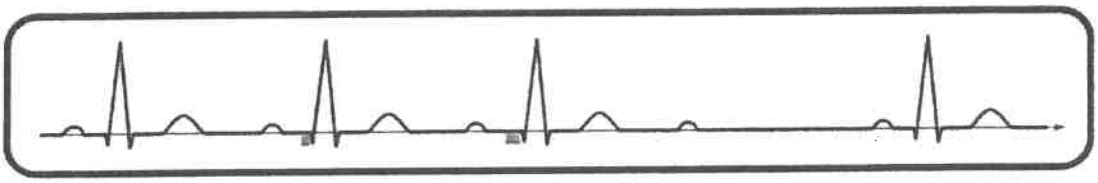
PQ-Zeit-Verlängerung

AV-Block 1. Grades PQ-Zeit > 0,20 s

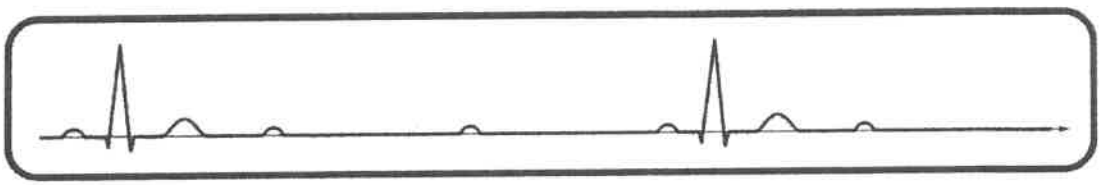


AV-Block 2. Grades (AVB II°)

Typ 1 (Wenckebach) PQ-Zeit zunehmend, bis eine Überleitung ausfällt.



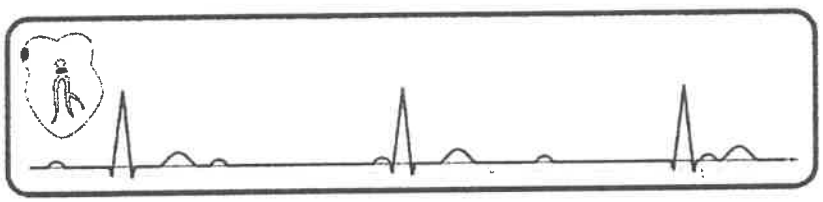
Typ 2 (Mobitz) AV-Überleitung nur bei jeder 2. (2:1 Periodik) oder jeder 3. (3:1 Periodik) Aktion.
PQ-Zeit kann normal sein.



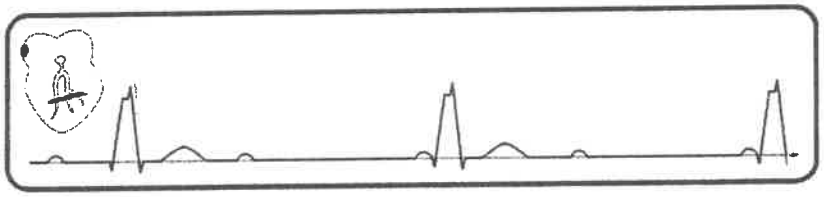
PQ-Zeit-Verlängerung

AV-Block III°
Keine AV-Überleitung
P-Wellen und Kammerkomplexe sind unabhängig voneinander
Langsamer Ersatzrhythmus

durch sekundäres Automatiezentrum oder



tertiäres Automatiezentrum (bei trifaszikulärem Block)



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   a) ST-Strecke
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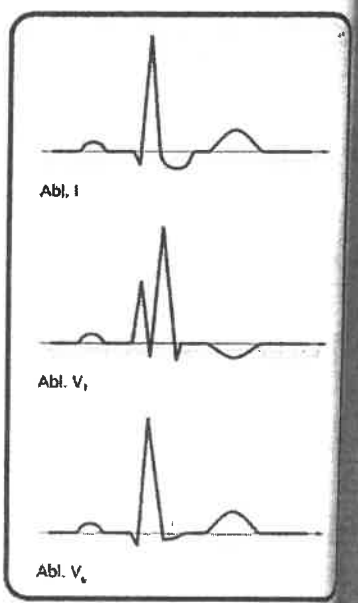
3. Erregungsausbreitung – QRS-Komplex

QRS-Breite
Normal: QRS-Dauer 60-100 ms

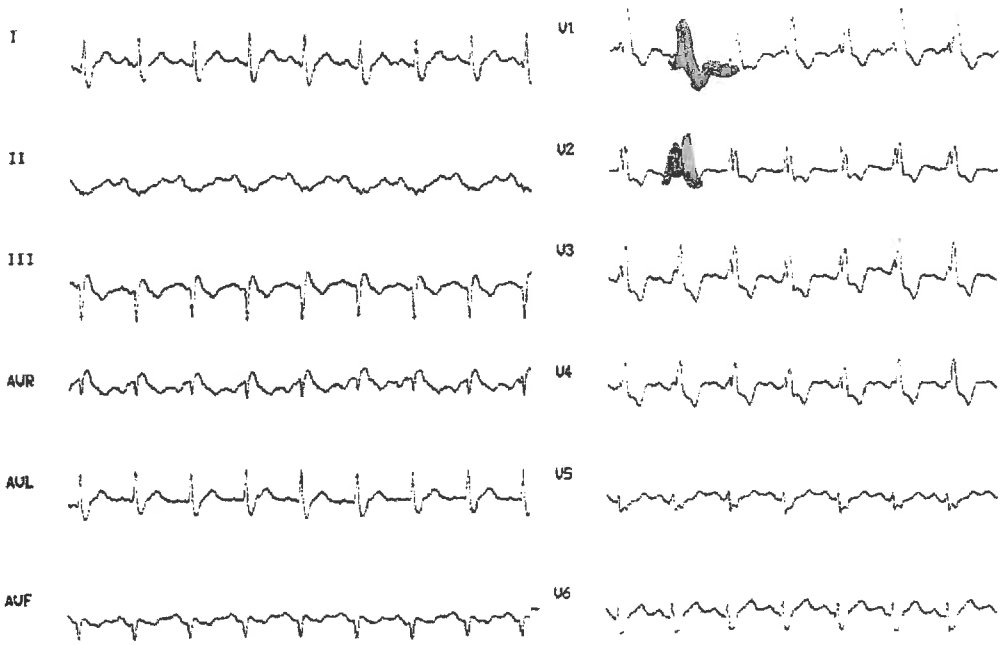
QRS-Verbreiterung
100-120 ms: intraventrikuläre Erregungsausbreitungsstörung
> 120 ms: Schenkelblock

Rechtsschenkelblock RSB
Oberer Umschlagspunkt (OUP) > 30 ms in V1
z.T. M-förmiger Kammerkomplex in V1 + V2
Plumpes S in V6, I und aVL
Großes R in V1 + QRS > 120 ms
(Großes R V1 + QRS < 120 ms Rechtsherzhypertrophie)

Inkompletter RSB
Selbe Konfiguration, aber QRS-Dauer < 120 ms



Rechtsschenkelblock - Beispiel



phys.: R wird zu Spitze o.ä.

3. Erregungsausbreitung – QRS-Komplex

Linksschenkelblock LSB

tiefe S Zacke V_1

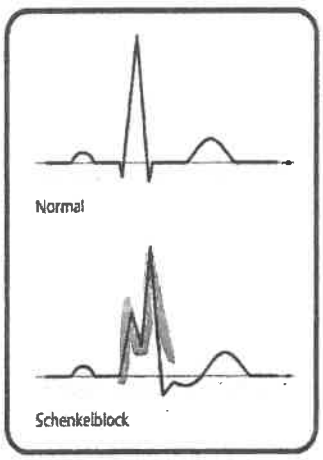
Oberer Umschlagspunkt (OUP) >50 ms in V6
z.T. M-förmiger Kammerkomplex in V5 + V6
Nie großes R in V1

+ AVL + I

Linksanteriorer Hemiblock LAHB: ÜLT + S bis V6

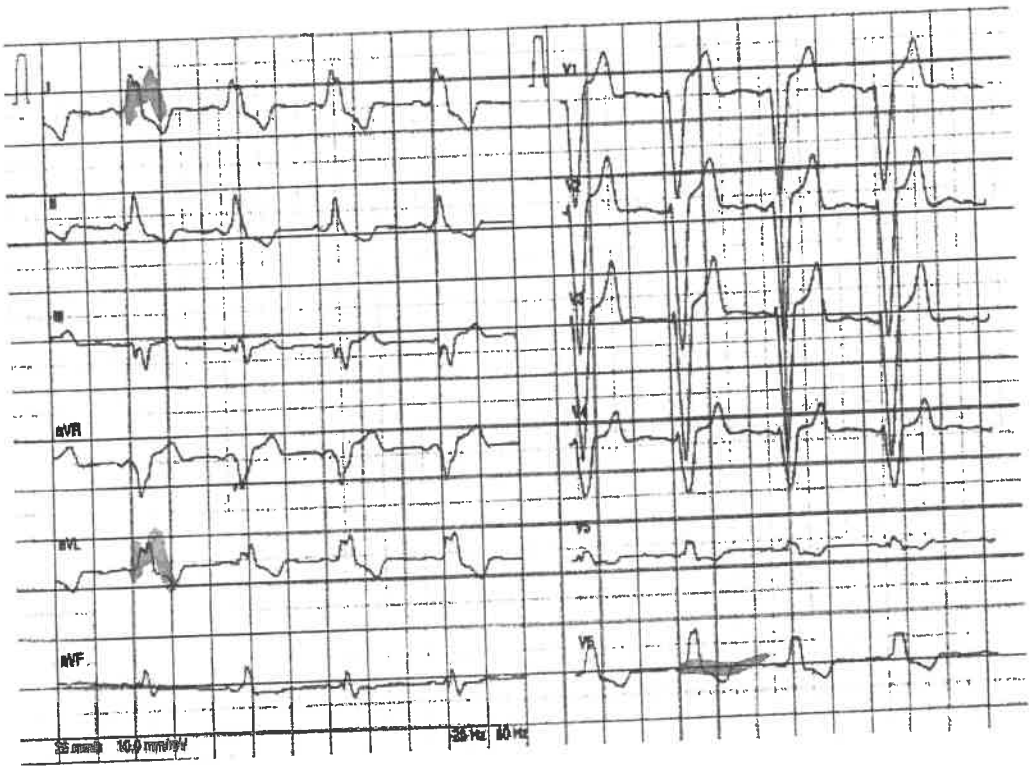
Linksposteriorer Hemiblock LPHB: Verdacht bei RT/ÜRT

Bifaszikulärer Block: RSB + LAHB, wenn zusätzlich AVB I°
dann droht AVB III°



Bei Blockbild konsekutive ERBS (Erregungsrückbildungsstörungen)

Linksschenkelblock - Beispiel



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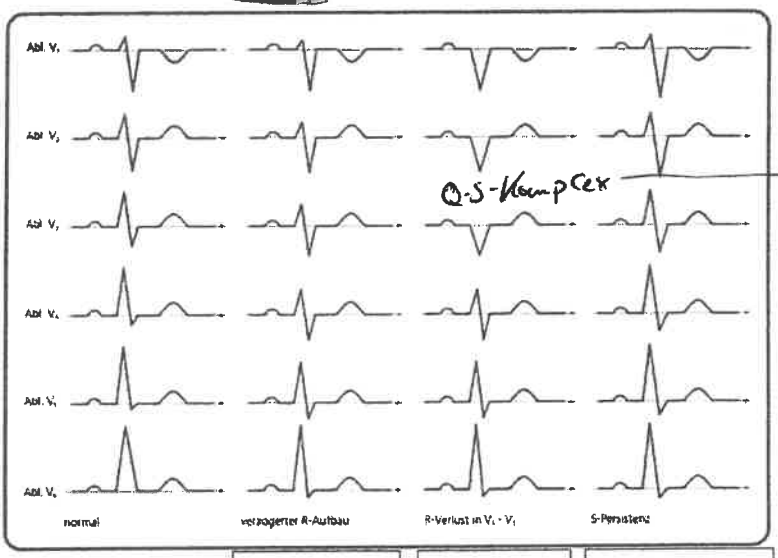
3. Erregungsausbreitung – R/S-Zacken

R-Progression – Normalbefund
R vergrößert sich von V2 zu V5
RS-Umschlagspunkt zwischen V2 – V4
Kein S in V6

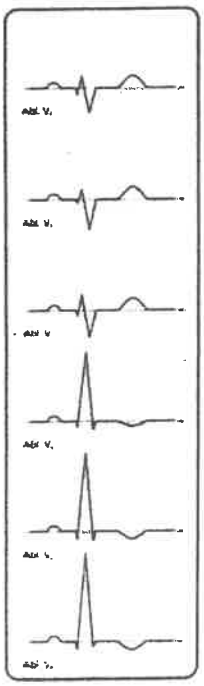


Pathologische Progression:

~~LAHB~~ ~~Infarkt~~ Linkshyper -trophie	Infarkt- narbe	~~LAHB~~ ~~Rechtsherz~~- belastung Thoraxform

3. Erregungsausbreitung – R/S-Zacken

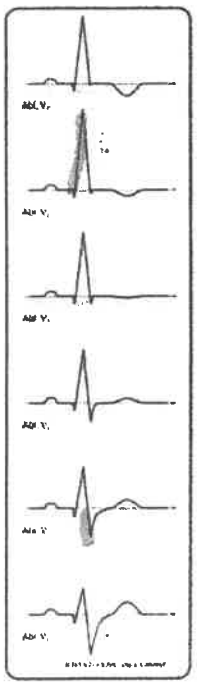
Linksherzhypertrophie



Sokolow-Lyon-Index (SLI) links:
~~S V1~~ + ~~R V5~~ od. ~~6~~
S V2 + R V6
positiv, bei ~~≥ 3,5 mV~~

Sokolow-Lyon-Index (SLI) rechts:
R V1 + S V5 od. 6
R V2 + S V6
positiv, bei > 1,05 mV

Rechtsherzhypertrophie



3. Erregungsausbreitung – R/S-Zacken

R-Zacken höhengemindert

Periphere Niedervoltage
R-Zacken in Extremitätenableitungen < 0,5 mV

totale **Zentrale Niedervoltage**
Zusätzlich R-Zacken in Brustwandableitungen < 0,7 mV

Ursachen:
- Adipositas
- Ödeme
- Perikarderguss
- Pleuraerguss
- Lungenemphysem
- Myxödem
- Amyloidose

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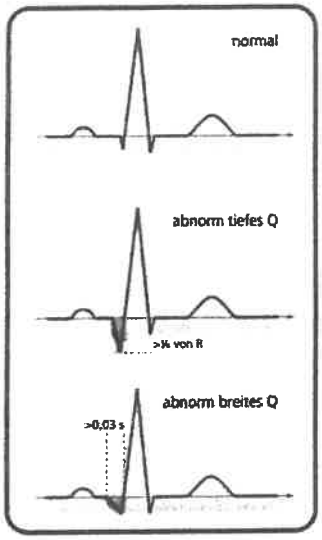
3. Erregungsausbreitung – Q-Zacken

Pathologische Q-Zacken

Brustwand vor R/S Umschlag
Extremitäten (Pardée Q)
> 0,03 s 30 ms
> ¼ R-Zacke
Infarktzeichen, HOCM

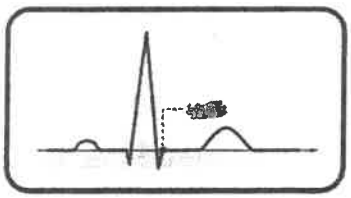


EKG-Befundung

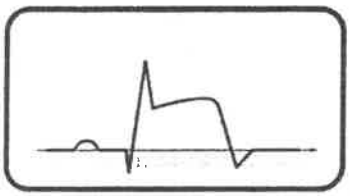
1. Lagetyp
2. Rhythmus und Frequenz
3. Erregungsausbreitung
   a) P-Welle
   b) PQ-Zeit
   c) QRS-Breite
   d) R/S-Umschlag, R und S in der Brustwand
   e) Q-Zacken
4. **Erregungsrückbildung**
   a) ST-Strecke
   b) T-Welle
   c) QT-Zeit

4. Erregungsrückbildung – ST-Strecke

ST-Streckenhebung
Messung 80 ms nach J-Punkt
(= Übergang von S in T)
Pathologisch > 0,1 mV in Extremitäten
> 0,2 mV in Brustwand
in 2 benachbarten Ableitungen

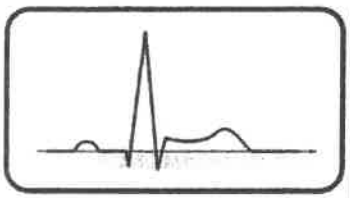


ST-Strecke aus absteigendem R
Transmurale Ischämie (Infarkt)
Herzwandaneurysma
Eher konvex
Lokal über Infarkt
Spiegelbildliche Senkungen



Infarrrrrrkt aus absteigendem RRRRR - lokalisiert

ST-Strecke aus aufsteigendem S
Perikarditis
Eher konkav
In allen Ableitungen



Perikarditisss aus aufsteigendem SSSS - überall

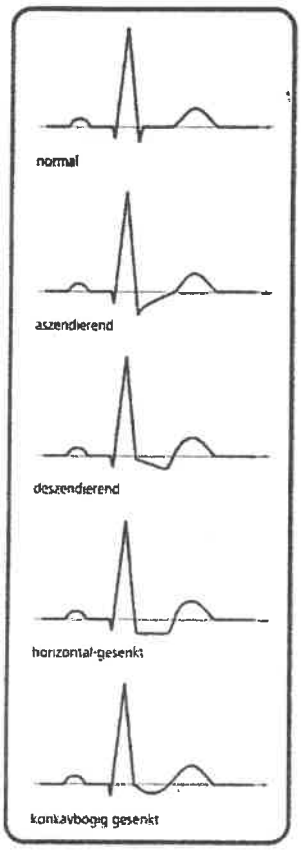
4. Erregungsrückbildung – ST- Strecke

ST-Streckensenkung

Aszendierend
Volumenhypertrophie
Ergometrisch = physiologisch

Horizontal ~~oder deszendierend~~
Nicht-transmurale Ischämie
Pathologisch → KHK

Muldenförmig
Digitalis



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   a) ST-Strecke
   b) T-Welle
   c) QT-Zeit

4. Erregungsrückbildung – T-Welle

T-Welle – Normalbefund
Halbrund
1/6 bis 2/3 R
Positiv oder konkordant neg.

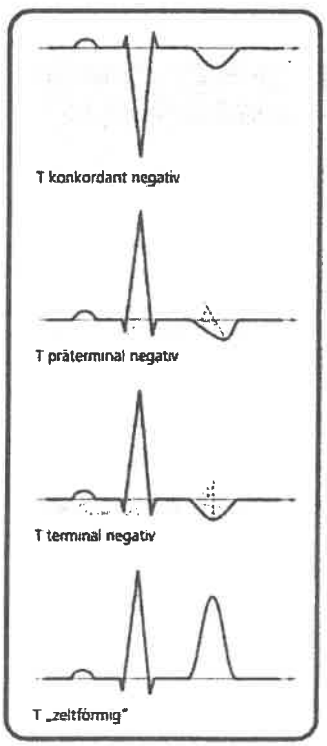
T-Negativierung Diskordant
Unspezifisch, Ischämie, Infarktfolge
Formen:

Präterminal negatives T
unspez.: Myocardschädigung, ischämisch, Metabolisch

Terminal negatives T
folgestadium MI, LE

Überhöhtes (zeltförmiges) T
„Vegetatives T", Erstickungs-T, Hyperkaliämie
Sportler, Vagotonus

Flaches T
Hypokaliämie



EKG-Befundung

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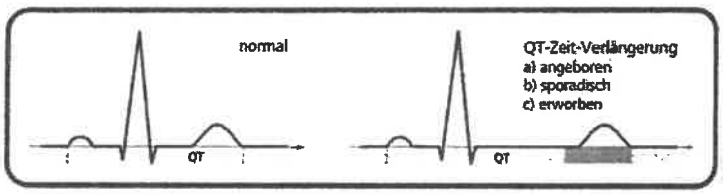
   a) ST-Strecke
   b) T-Welle
   c) QT-Zeit

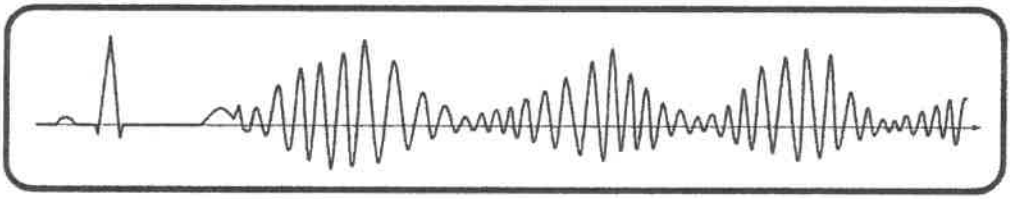
4. Erregungsrückbildung – QT-Zeit

QT-Zeit
Norm: frequenzabhängig
frequenzkorrigiert < 440 ms

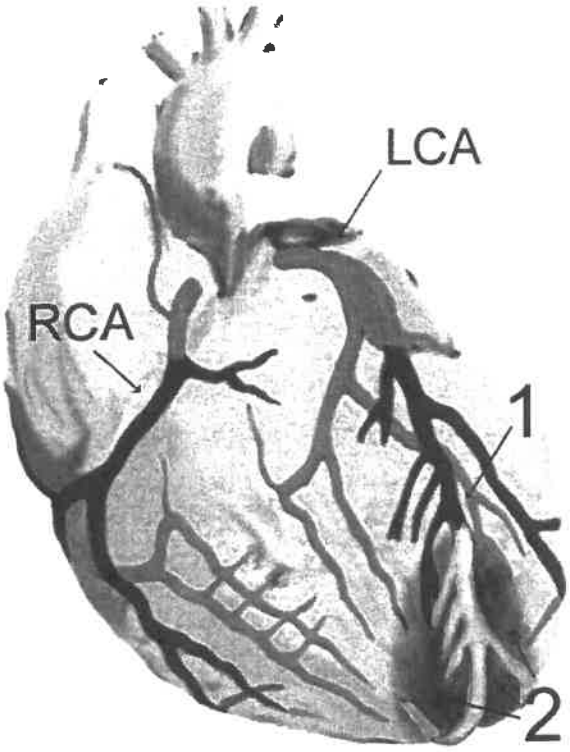


QT-Zeit-Verlängerung
Ursachen:
- Veranlagung (long-QT-Syndrom)
- Medikamente (Antidepressiva, Makrolide, MCP, Chinin)
- Elektrolytstörungen (Hypokaliämie, Hypokalzämie)

Komplikationen:
Ventrikuläre Tachykardie (VT), Kammerflimmern (VF)
Torsade-de-pointes-Tachykardie (spezielle VT):
Hochfrequente ventrikuläre Aktion mit Torsionsbewegung der R-Zacken um die Grundlinie.



Koronararterien und EKG-Lokalisation



„Autor Jheuser", 01.08.2010, Lizenztext siehe Anhang; http://de.wikipedia.org/w/index.php?title=Datei:AMI_scheme.png&filetimestamp=20060619165758

Linke Koronararterie (LCA)
- R. interventr. ant. (RIVA)
  - Distaler R. interventr. ant. → **V1-V4** (Herzspitze)
  - R. diagonalis → **I, aVL, V5-V6** (laterale Wand)
- R. circumflexus (RCX) → **II, III, aVF** + ggf. V7-9 V5/6 (posteriore Hinterwand)

Rechte Koronararterie (RCA) → **II, III, aVF** + VR3-6 bei Rechtsherzbeteiligung (inferiore/diaphragmale Wand)

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Herzinfarkt - Stadien

Initialstadium:
1. Hochpositive, schmale T-Welle (sog. „Erstickungs-T")

Akutstadium:
2. ST-Strecken-Hebung über Infarktgebiet
   ST-Hebung aus absteigendem R
   ST-Senkungen gegenüber dem Infarktgebiet

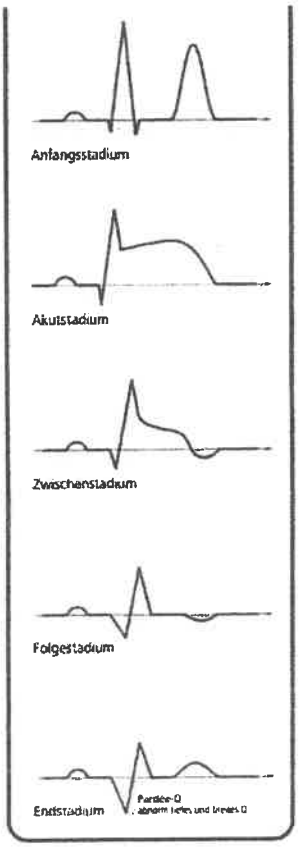
Zwischen- und Folgestadium:
3. Rückbildung der ST-Streckenhebungen

4. T-Negativierung

5. R-Verlust

6. Q-Zacken-Bildung

Endstadium (4 Wochen):
7. T-Welle wird positiv (kann auch negativ bleiben)
   R-Verlust persistiert meistens
   Tiefes und breites Q über dem Infarktgebiet



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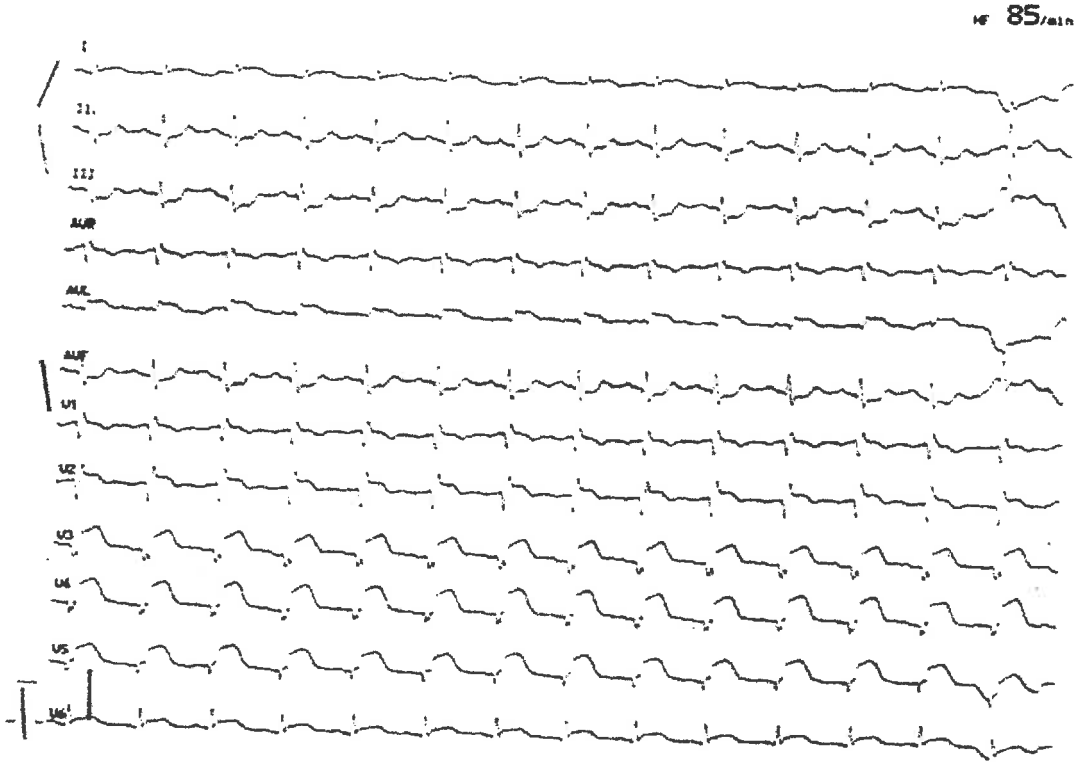
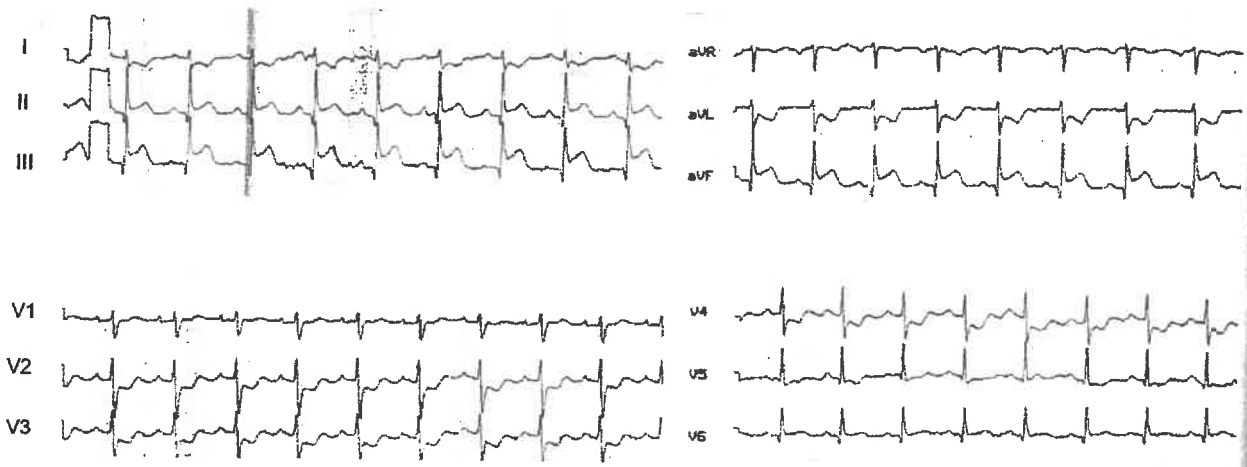
Ausgedehnter akuter Vorderwandinfarkt



Direkte Infarktzeichen: I, AVL, V2 – V6
Indirekte Infarktzeichen: II, III, AVF, V1

Problem: Verschluss prox. RIVA

Akuter Hinterwandinfarkt



Direkte Infarktzeichen: II, III, AVF
Indirekte Infarktzeichen: I, AVL, V1 – V5

Problem: Verschluss RIVP Ramus interventricularis post. (RCA), hier Rechtsversorger

EKG bei Rechtsherzbelastung
(z.B. bei Lungenarterienembolie)

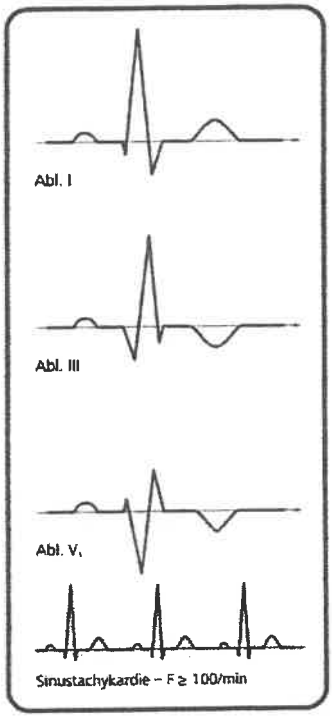
Steiltyp, Rechtstyp, überdrehter Rechtstyp, Sagittaltyp (SI-QIII-Typ)

Sinustachykardie (Lungenembolie)

P-dextroatriale

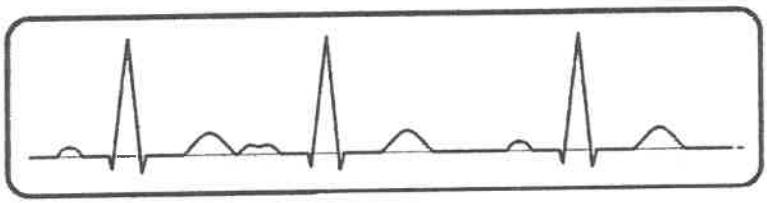
Rechtsschenkelblock (auch inkomplett)
- Konsekutive ERBS

T-Negativierung/ ST-Segmenterhöhungen V1-3



Supraventrikuläre HRST

Supraventrikuläre Extrasystole, singulär
Vorzeitige P-Welle mit oft anderer Konfiguration, QRS wie bei Sinusschlag

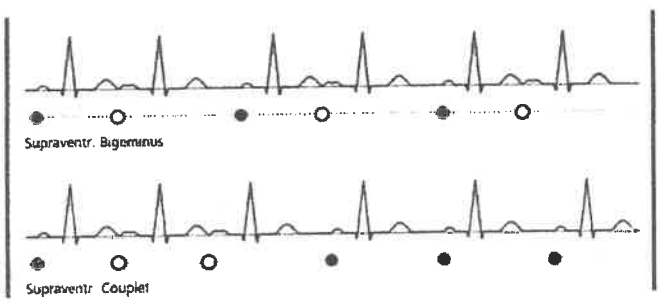


Trigeminus
1 x NS gefolgt von 2 x ES

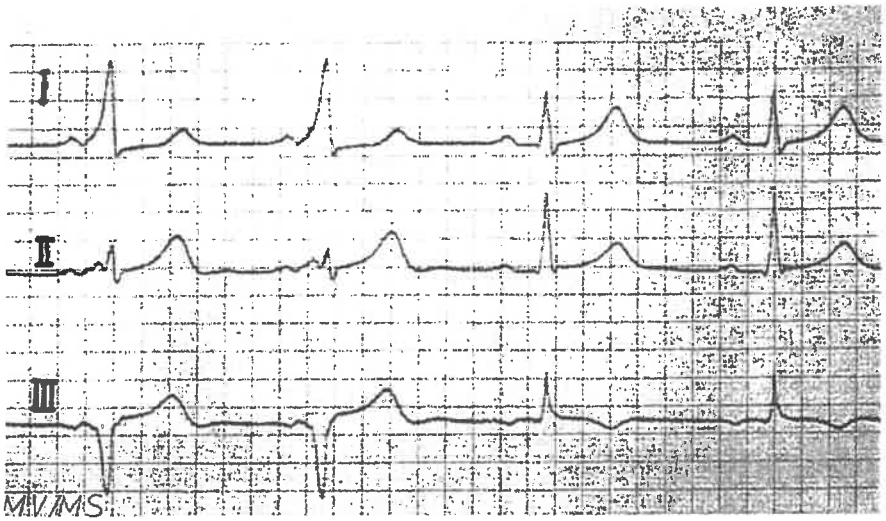
Bigeminus
Jeder NS gefolgt von ES

Couplet
2 ES hintereinander

Triplet
3 ES hintereinander



Supraventrikuläre HRST



IMPP, intermit. Delta-Welle

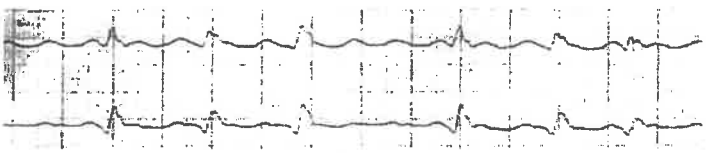
WPW:

In Ruhe: Deltawelle mit verkürzter PQ-Zeit, QRS-Komplex verbreitert

Im Anfall: typischerweise Schmalkomplextachykardie (orthodrome Leitung) ohne P-Wellen mit HF 160-220/min

Supraventrikuläre HRST

Vorhofflattern
Vorhoffrequenz 250- 350/min
sägezahnartig
da meist mit AV-Block verbunden: Überleitung wechselnd, 2:1 bis 4:1



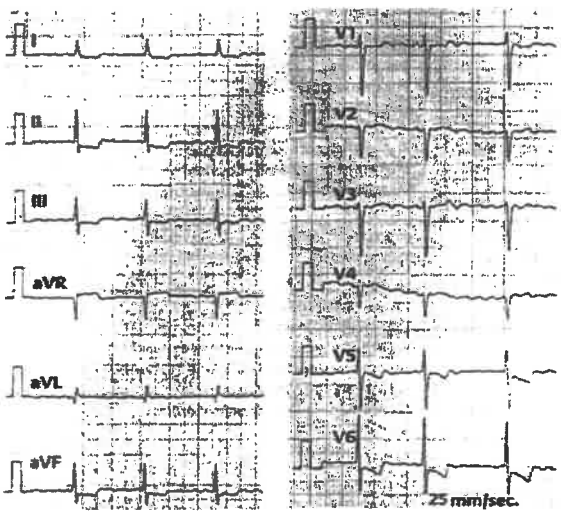
Typisch (nach der Regel): in II, III, aVF negativ
Atypisch (gegen die Regel): in II, III, aVF positiv

Vorhofflimmern
Vorhoffrequenz > 350/min

Überleitung verschieden möglich

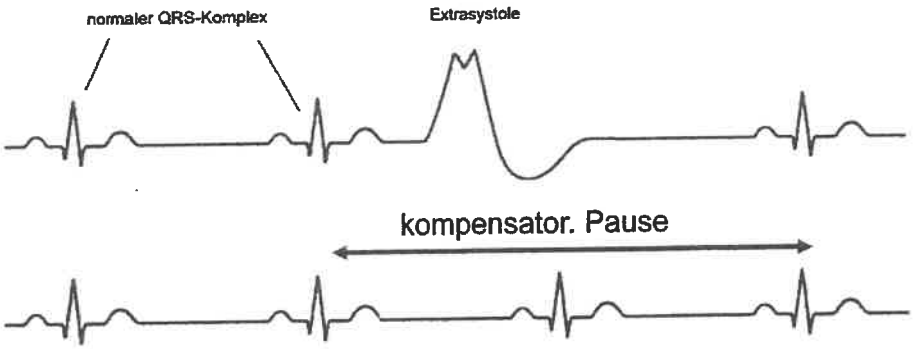
absolute Arrhythmie (R-R-Abstände unterschiedlich lang)

Pulsdefizit bei der körperlichen Untersuchung



Ventrikuläre HRST

Ventrikuläre Extrasystole, singulär
Vorzeitige Kammerkontraktion mit meist verbreitertem QRS-Komplex
Keine vorhergehende P-Welle
Kompensatorische Pause



Trigeminus
1 x NS gefolgt von 2 x ES

Bigeminus
Jeder NS gefolgt von ES

Couplet
2 ES hintereinander

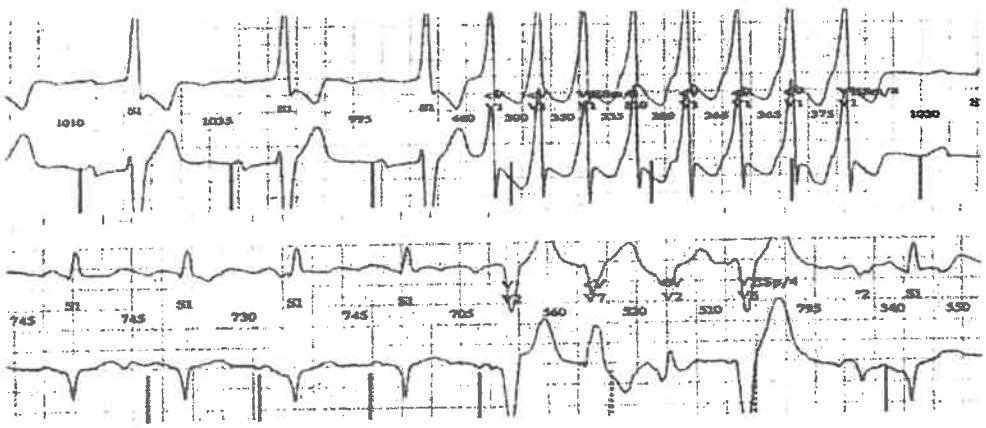
Triplet
3 ES hintereinander

Ventrikuläre HRST

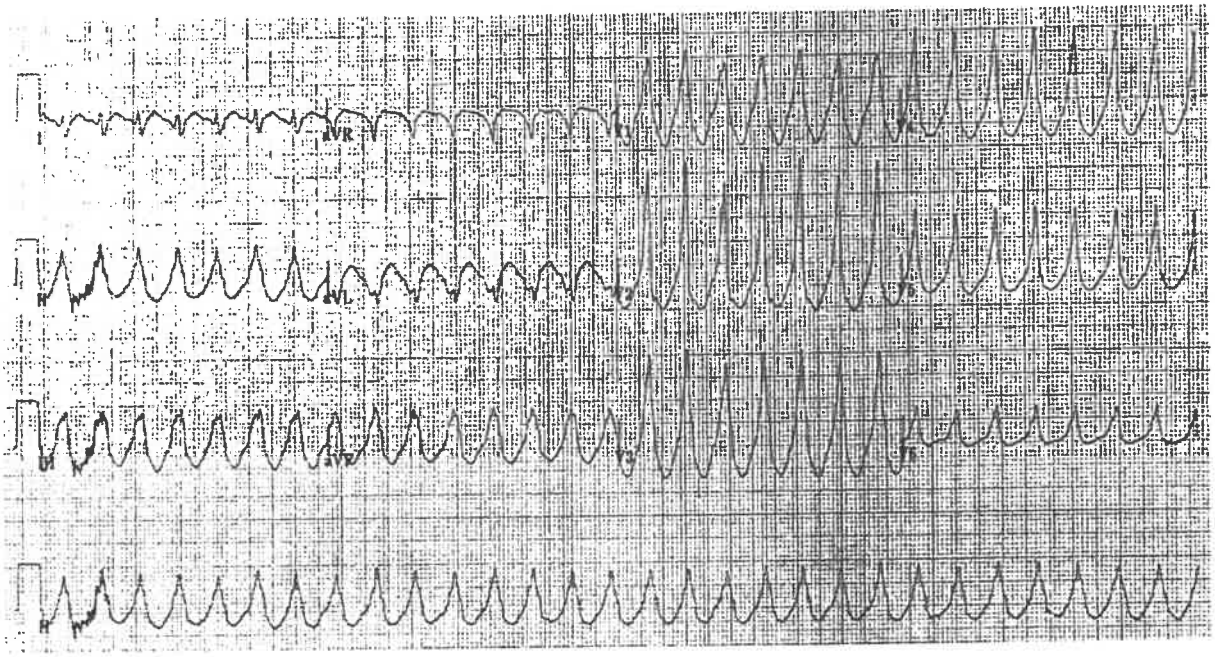
Ventr. Salve
Vorkommen:
z.B. nach Myokardinfarkt

Monomorph
(Erregung von einem Ort des Ventrikel-Myokards ausgehend)

Polymorph
(Erregung geht von mehreren Orten aus)



Ventrikuläre Tachykardie
Herzfrequenz > 150/min.
Erregungsursprung distal des His-Bündel
Regelmäßige, breite Kammerkomplexe (> 120 ms)

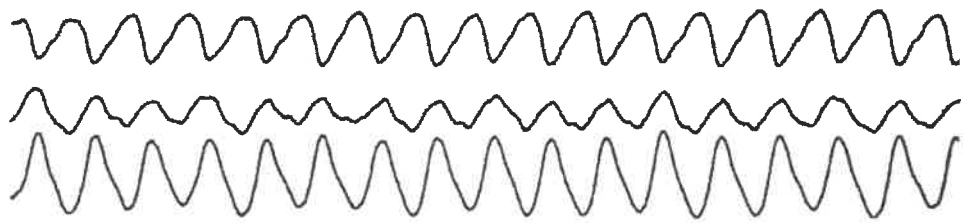


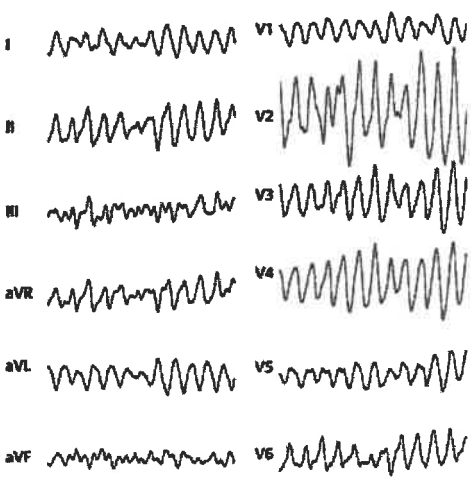
Kammerflattern

200 (240) – 300/min gleichmäßige Kammerkomplexe ohne isoelektrische Linie

Kammerflimmern

> 300/min ungleichmäßige oszillierende Kammerkomplexe ohne isoelektrische Linie, teils wellen- und zackenförmig





EKG-Analyse bei Tachykardie

1. Pat. hämodynamisch stabil oder instabil? → je instabiler desto Strom
2. Schmale (< 0,12 s) oder breite (≥ 0,12 s) Kammerkomplexe?
3. Regelmäßige oder unregelmäßige Tachykardie?

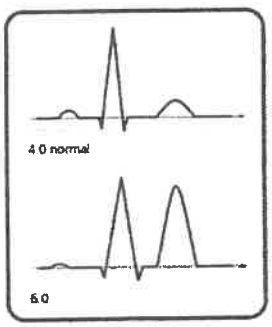
	Schmale Komplexe	Breite Komplexe
Regelmäßig	Sinustachykardie Vorhofflattern AV-Knoten-Reentry WPW (orthodrom)	Ventrik. Tachykardie Kammerflattern WPW (antidrom) Supraventr. Tachykardie mit Schenkelblock
Unregelmäßig	TAA bei VHF Sinustachykardie mit SVES	Kammerflimmern Torsade de Pointes VHF mit Schenkelblock WPW mit VHF

EKG bei Elektrolytstörungen Kalium

Hyperkaliämie > 5 mval

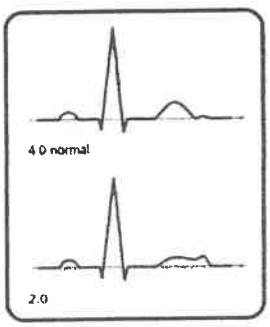
- Flache P-Welle
- PQ-Dauer vergrößert
- QRS-Komplex verbreitert
- Zeltförmiges T
- Ggf. Verschmelzung von QRS-Komplex und T-Welle

QT verkürzt

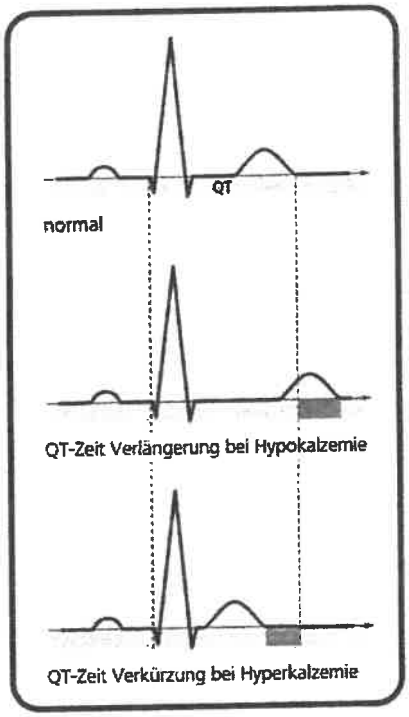


Hypokaliämie

- Ggf. deszendierende ST-Senke
- Abflachung der T-Welle
- U-Welle
- Ggf. T-U-Verschmelzungswelle
- Verlängerte QT-Zeit



EKG bei Elektrolytstörungen Kalzium



Schrittmacher-EKG

Schrittmacherkodierung:

1. Buchstabe: Stimulationsort

2. Buchstabe: Wahrnehmungsort/ Detektionsort

3. Buchstabe: Betriebsart/ Reaktionsart

Verwendete Abkürzungen:

A = Atrium, V = Ventrikel, I = Inhibition, D = Dual

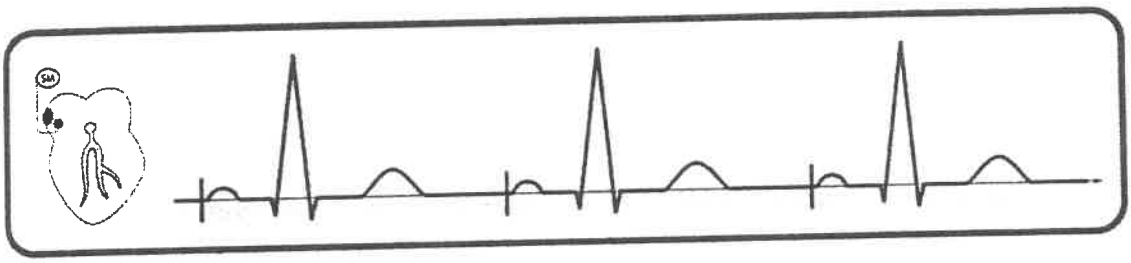
Inhibition: Impulsabgabe wird bei Spontanerregung des Herzens inhibiert.
Triggerung: Impulsabgabe erfolgt bei Spontanerregung des Herzens in Refraktärphase.

AAI-Schrittmacher

AAI:
Stimulation im rechten Vorhof
Wahrnehmung im rechten Vorhof
Inhibition durch Eigenrhythmus
Einkammer-SM

EKG: Vorhofspike gefolgt von Depolarisation im Vorhof

Indikation:
Sick-Sinus-Syndrom
wichtig: restliches Erregungsleitungssystem muss intakt sein



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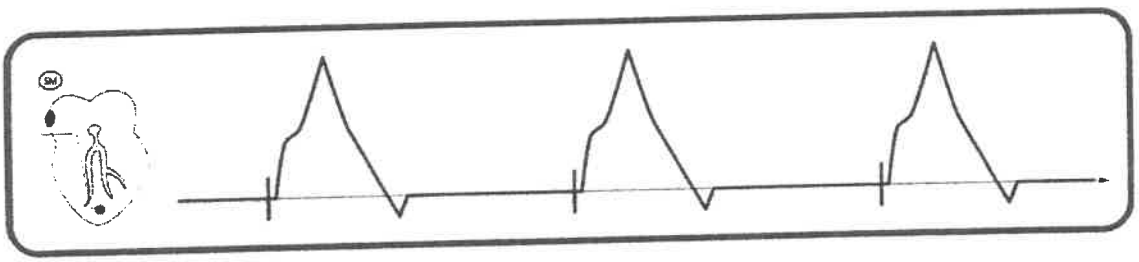
VVI-Schrittmacher

VVI (am häufigsten):
Stimulation im rechten Ventrikel
Wahrnehmung im rechten Ventrikel
Inhibition durch Eigenrhythmus
Einkammer-SM

EKG: Schrittmacherspike gefolgt von Depolarisation im Ventrikel
schenkelblockartige Deformierung des QRS-Komplexes

Indikation: BAA bei chron. VHF

Komplikation:
Schrittmachersyndrom durch fehlende Synchronität zwischen Vorhof und Ventrikel bei erhaltener Vorhoffunktion



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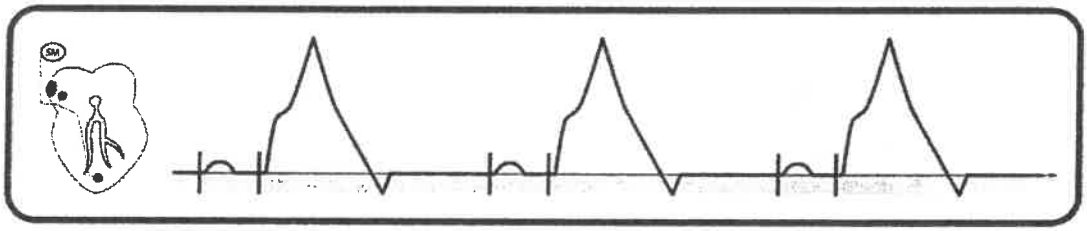
DDD-Schrittmacher

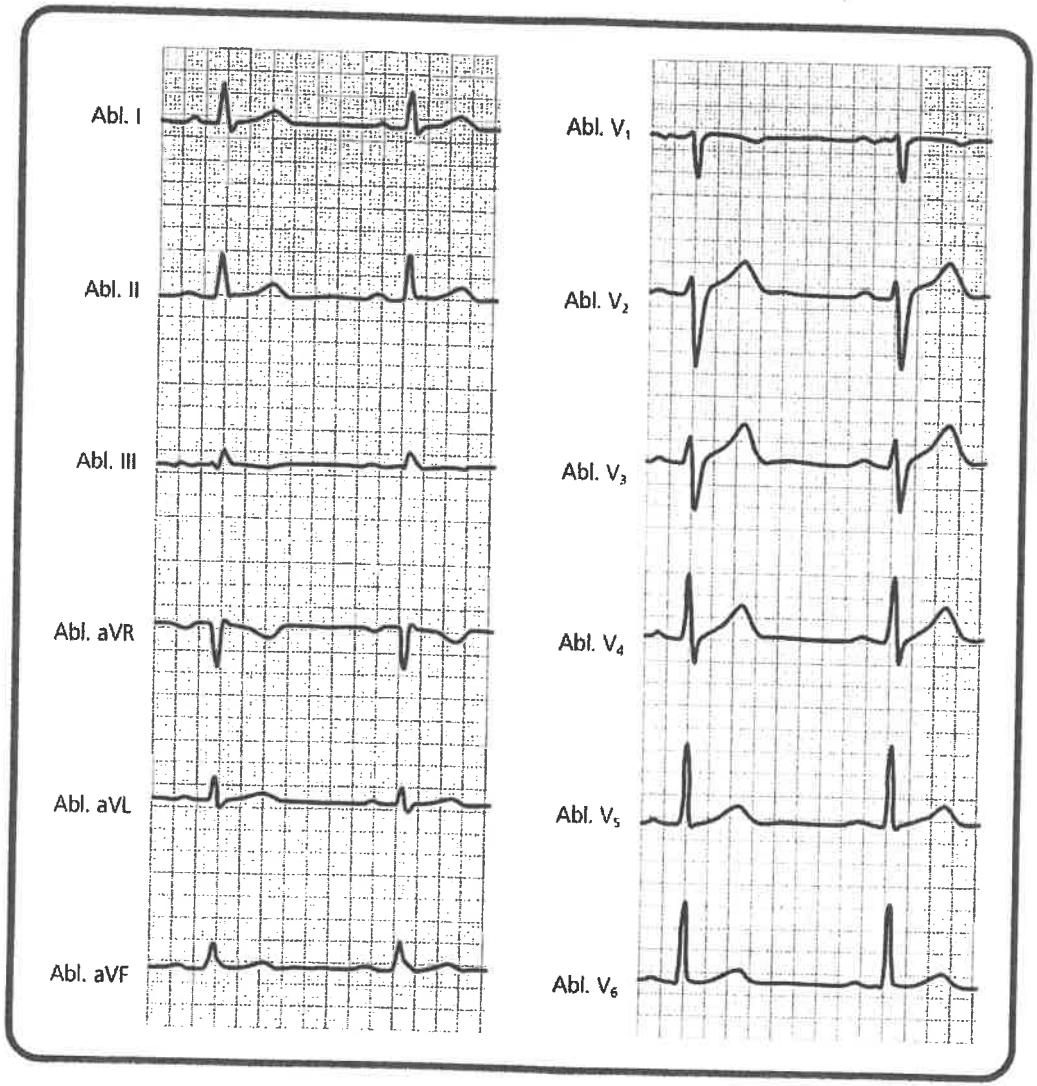
DDD:
Stimulation in rechten Vorhof und Ventrikel
Wahrnehmung in Vorhof und Ventrikel
Inhibition oder Triggerung
Zweikammer-SM
Sonderform Bivent: Dreikammmer-SM, zusätzlich Elektrode an linkem Ventr.

EKG: Schrittmacherspikes in Vorhof und Ventrikel oder nur Ventrikel bei erhaltenem SR, schenkelblockartige Deformierung des QRS-Komplexes

Indikation:
AV-Block Grad II (Mobitz)
AV-Block Grad III

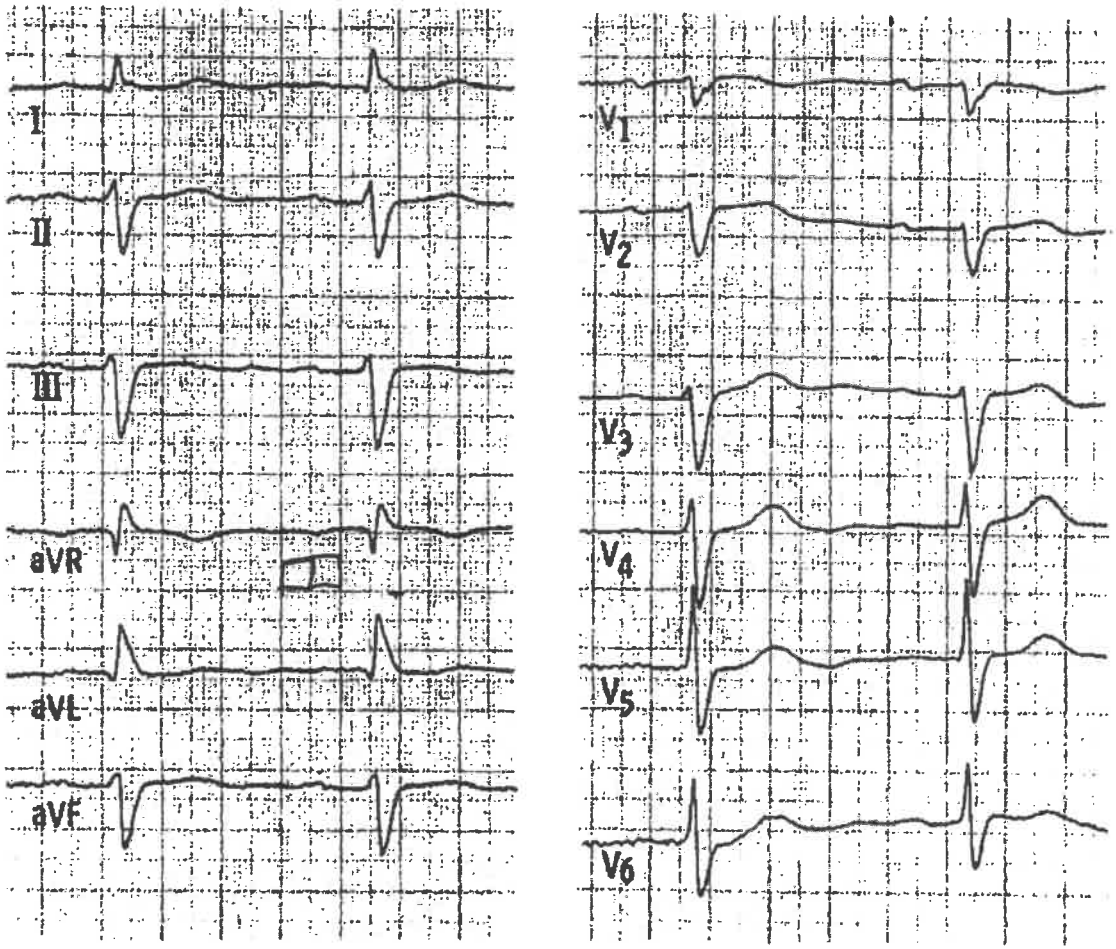


Beispiel-EKG 1



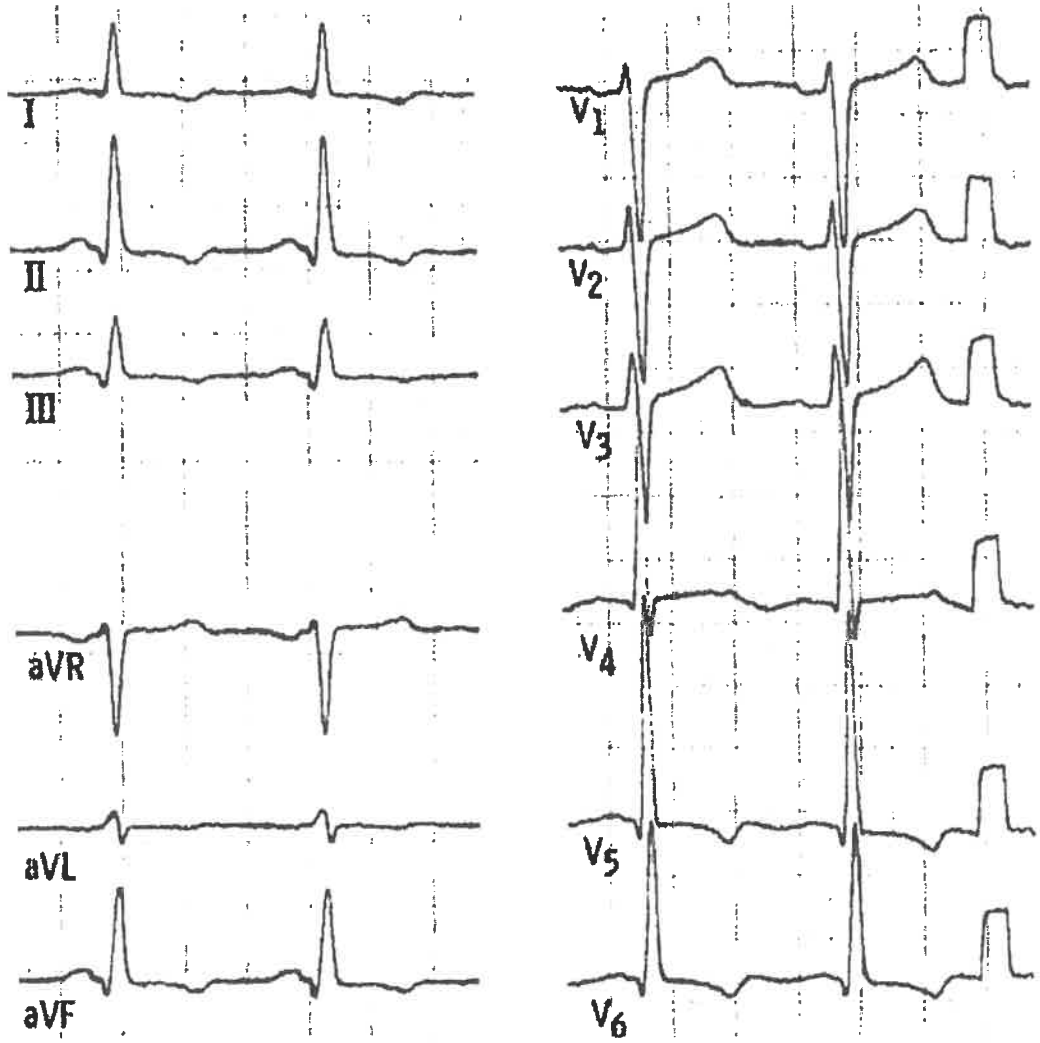
Papiervorschub:
50 mm/Sekunde

Beispiel-EKG 2



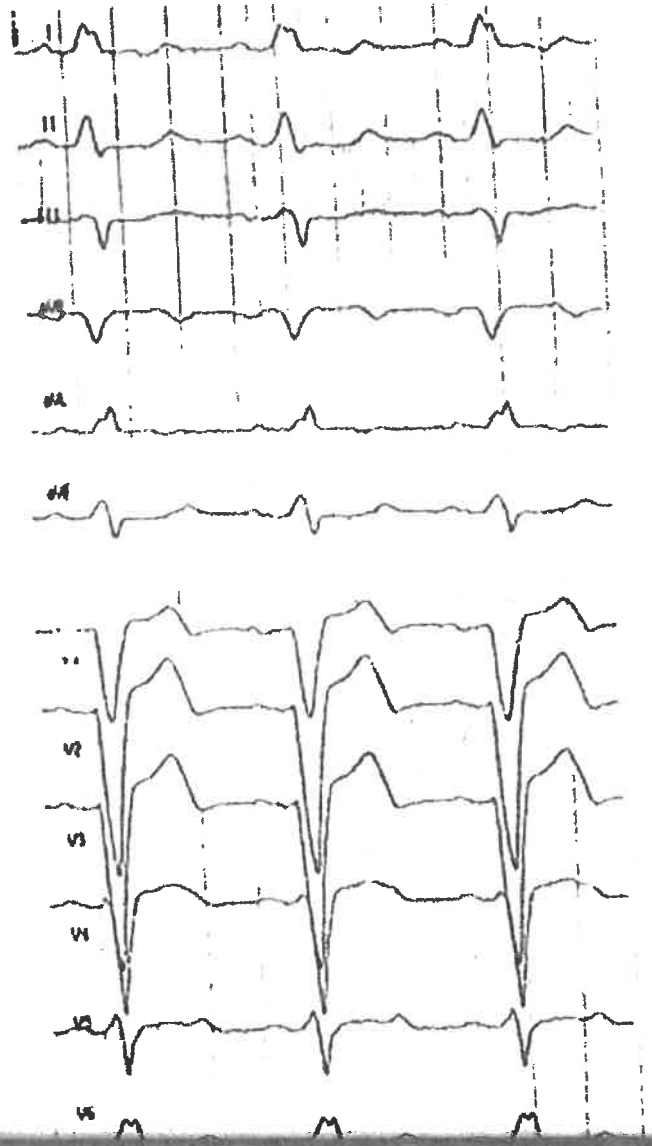
Papiervorschub:
50 mm/Sekunde

Beispiel-EKG 3



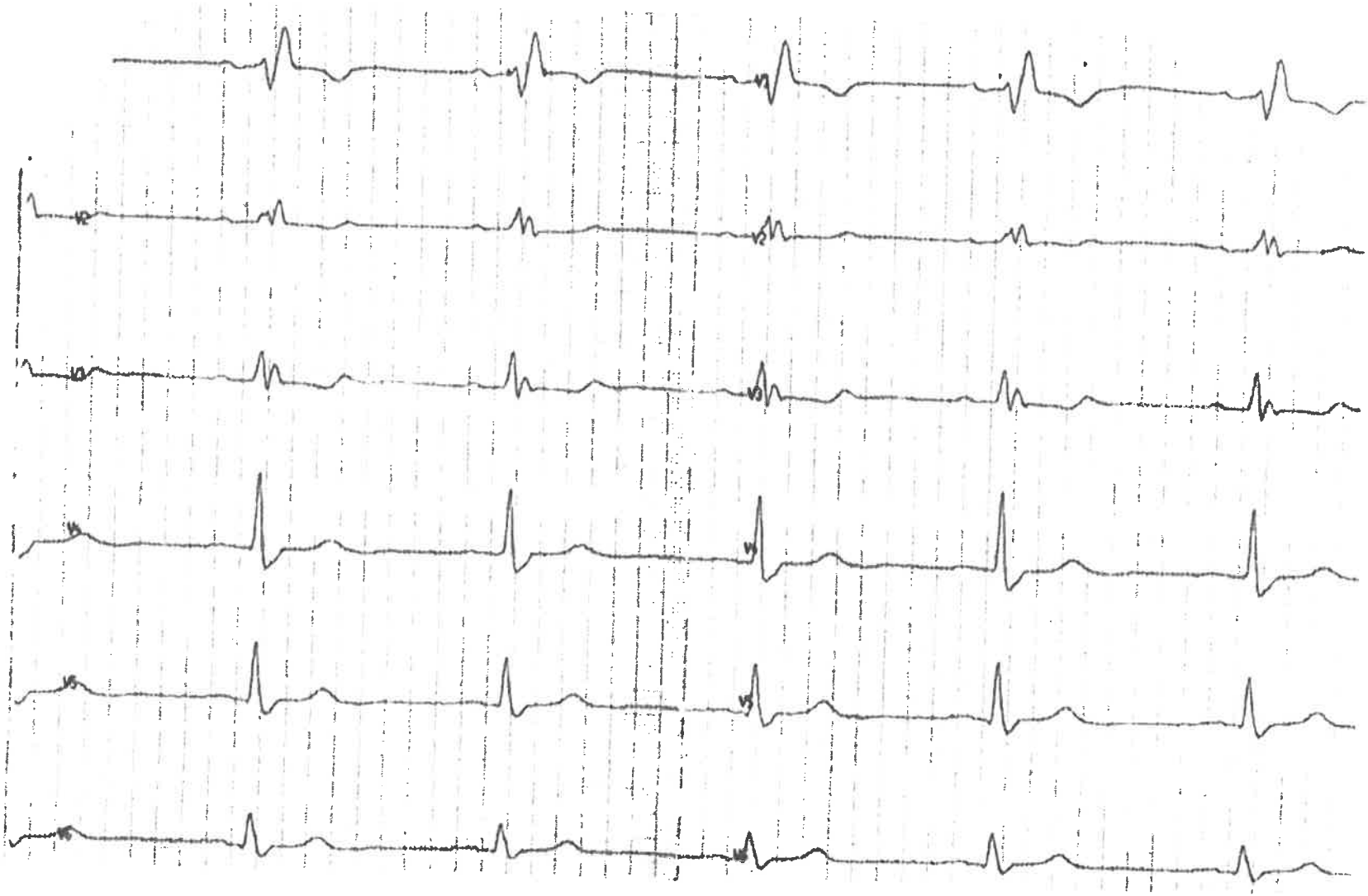
Papiervorschub:
50 mm/Sekunde

Beispiel-EKG 4



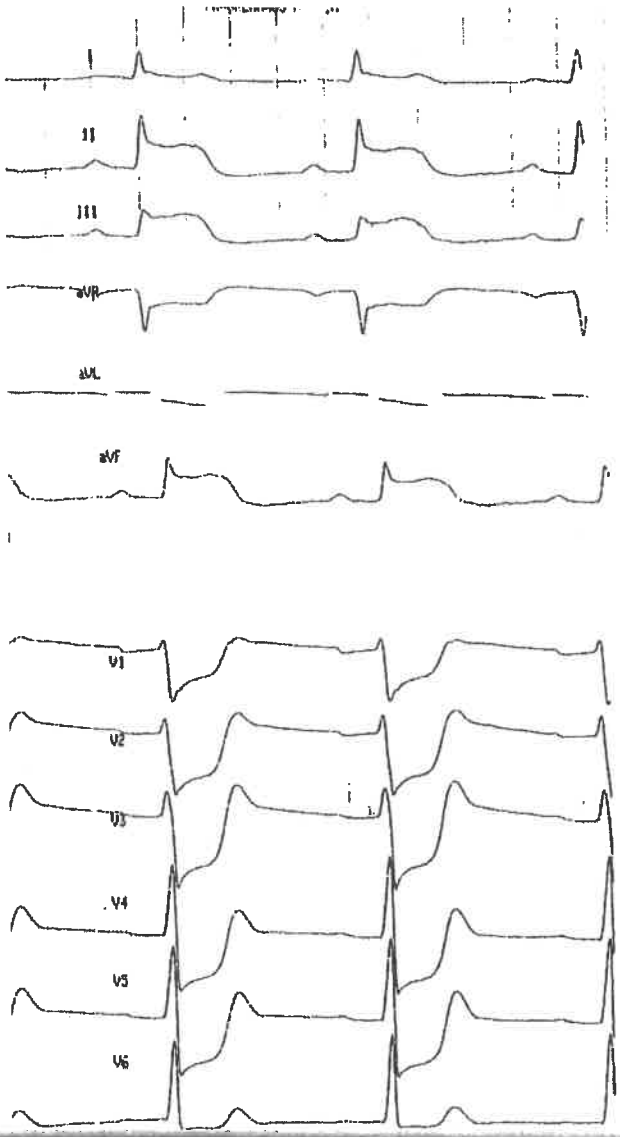
Papiervorschub:
50 mm/Sekunde

Beispiel-EKG 5



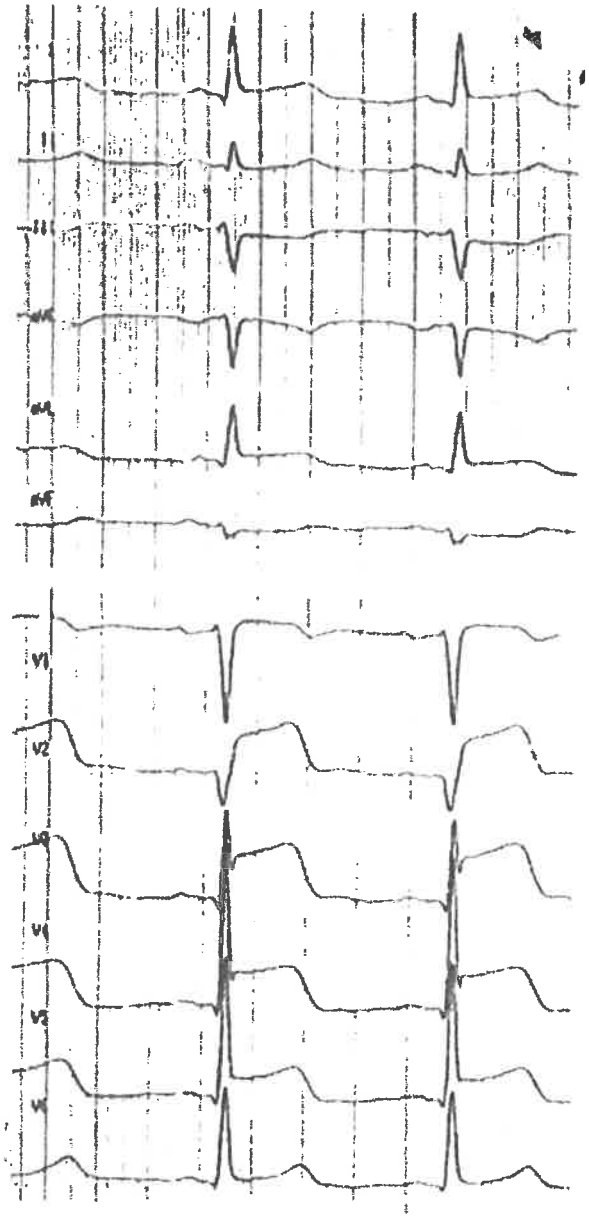
Papiervorschub: 50 mm/Sekunde

Beispiel-EKG 6



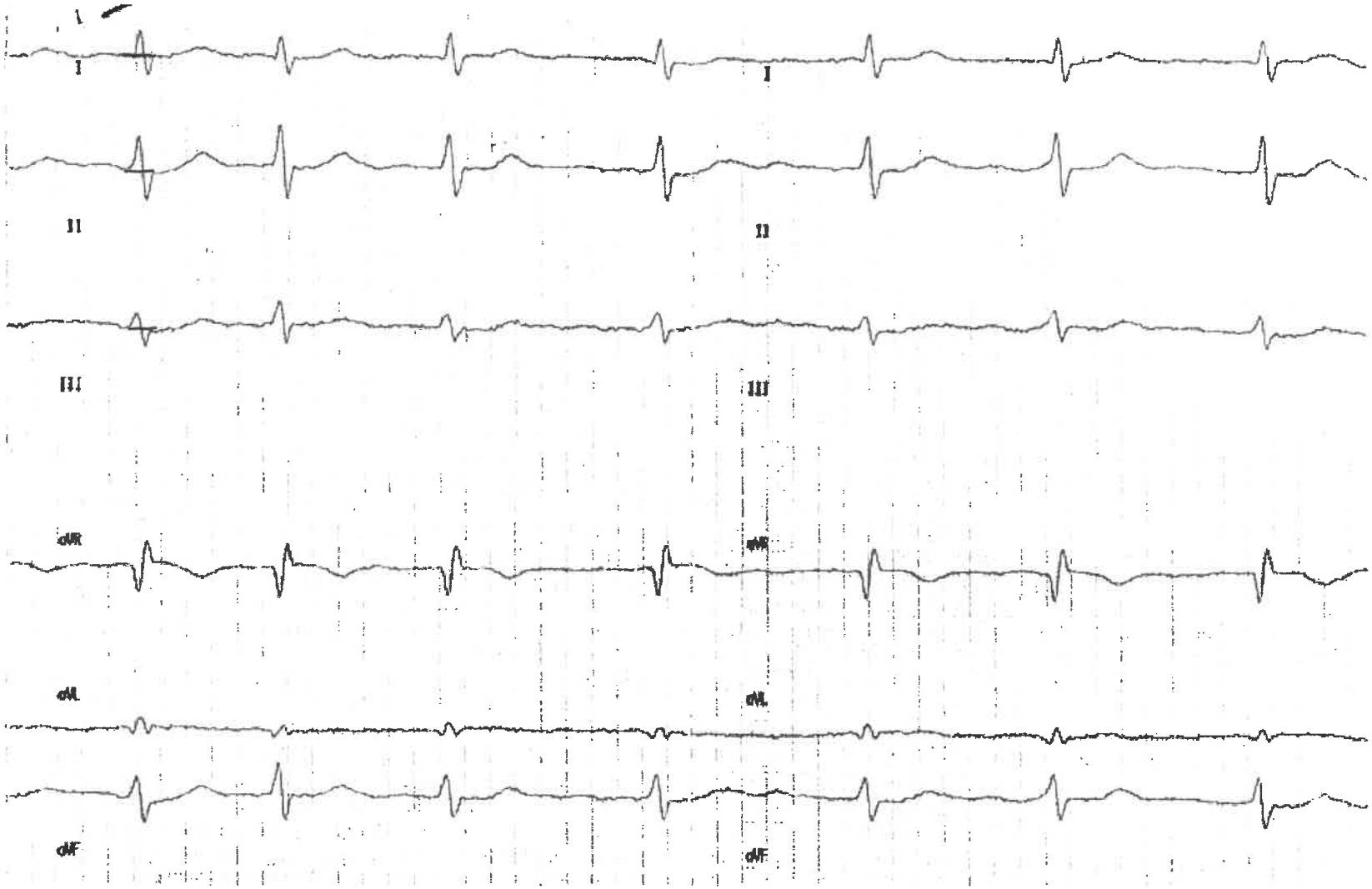
Papiervorschub:
50 mm/Sekunde

Beispiel-EKG 7



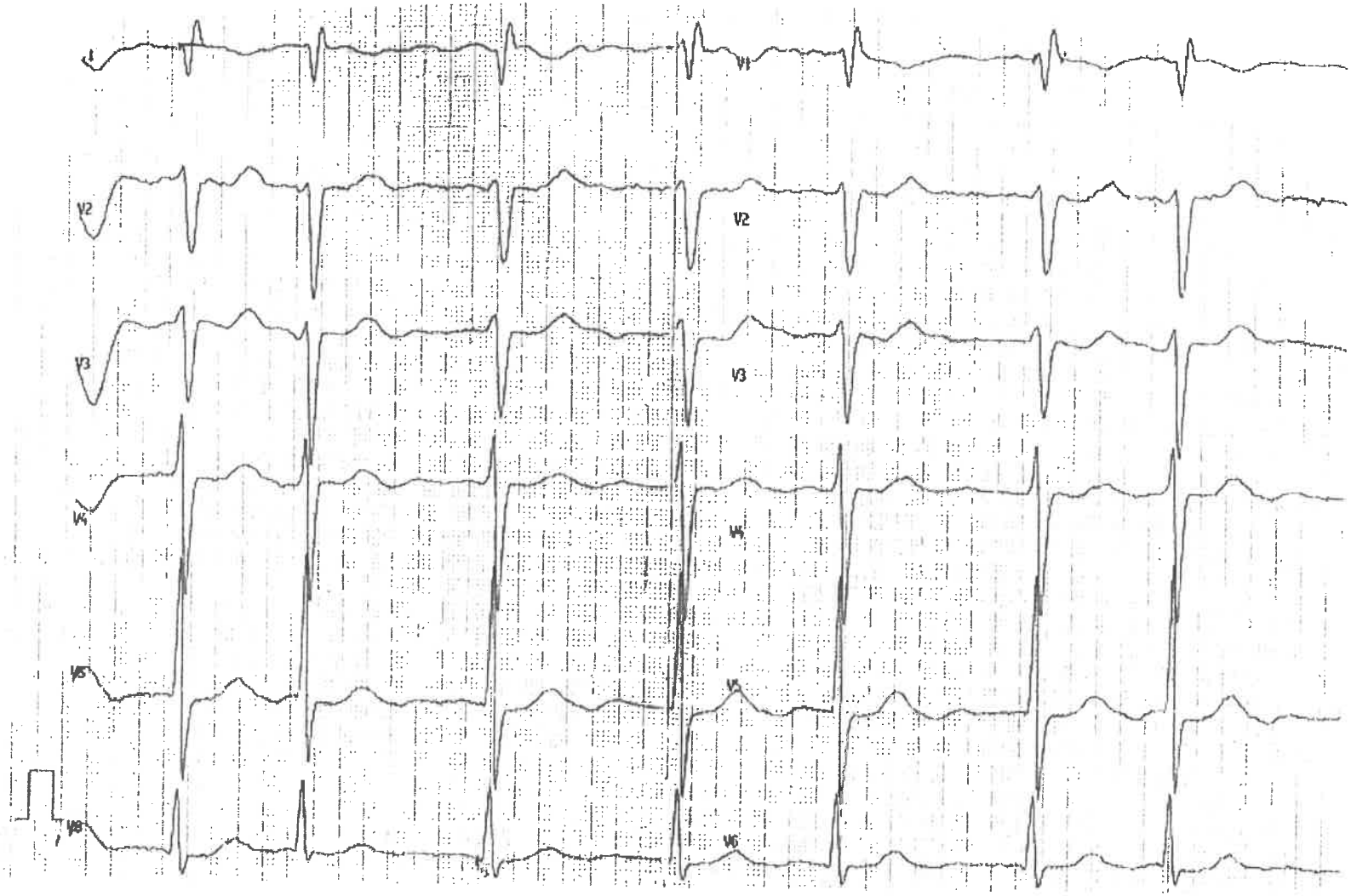
Papiervorschub:
50 mm/Sekunde

Beispiel-EKG 8.1



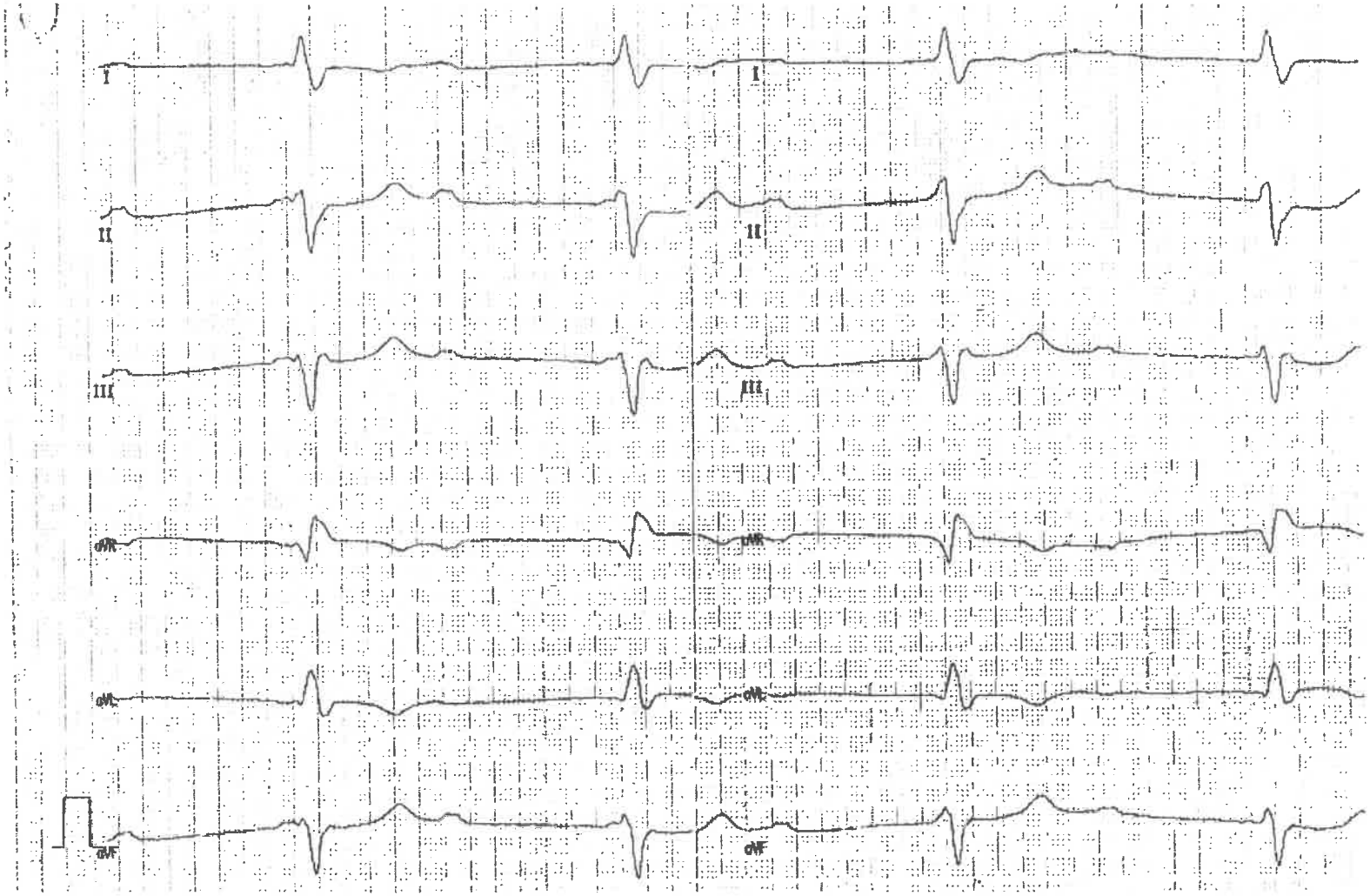
Papiervorschub: 50 mm/Sekunde

Beispiel-EKG 8.2



Papiervorschub: 50 mm/Sekunde

Beispiel-EKG 9.1



Papiervorschub: 50 mm/Sekunde

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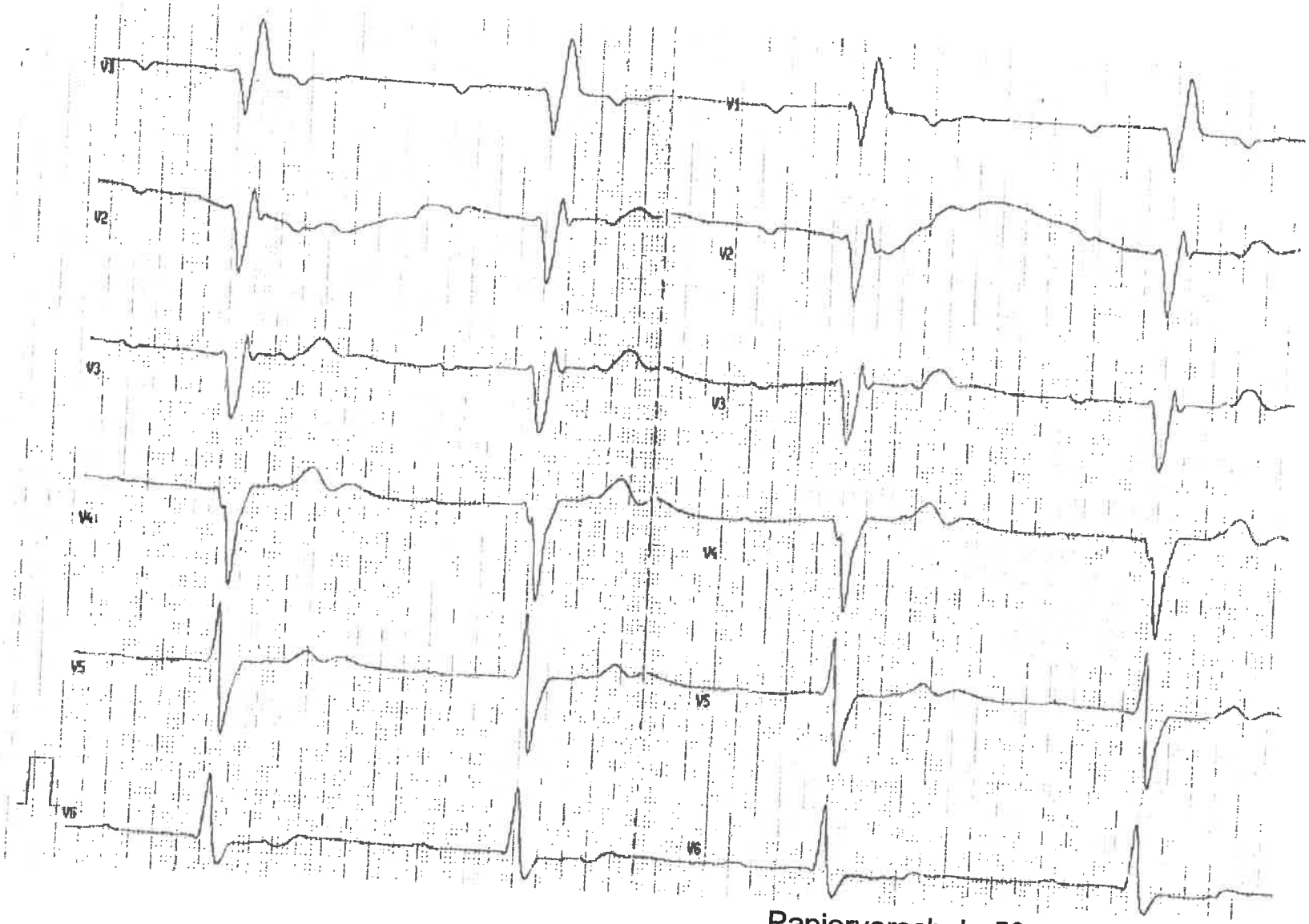
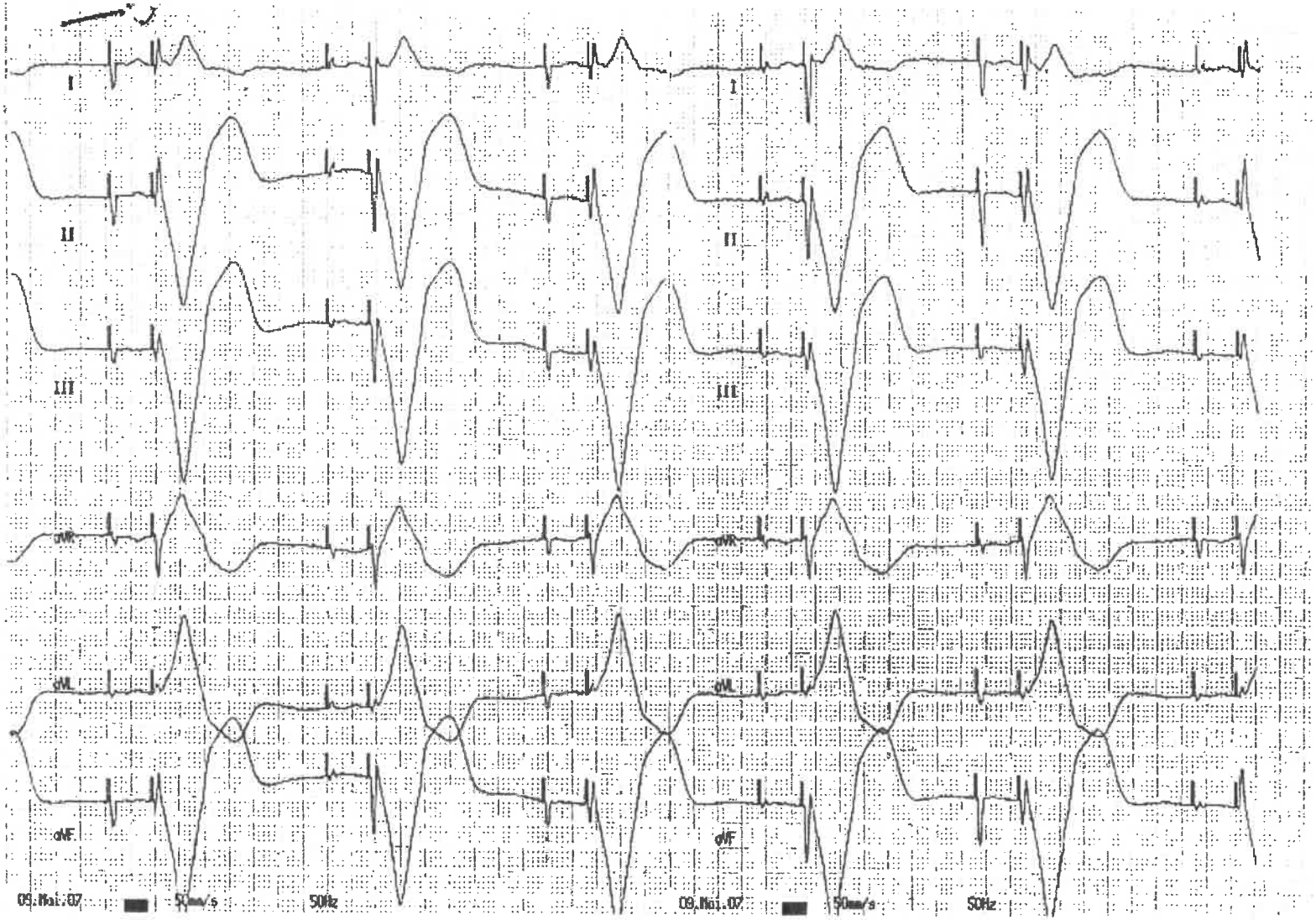


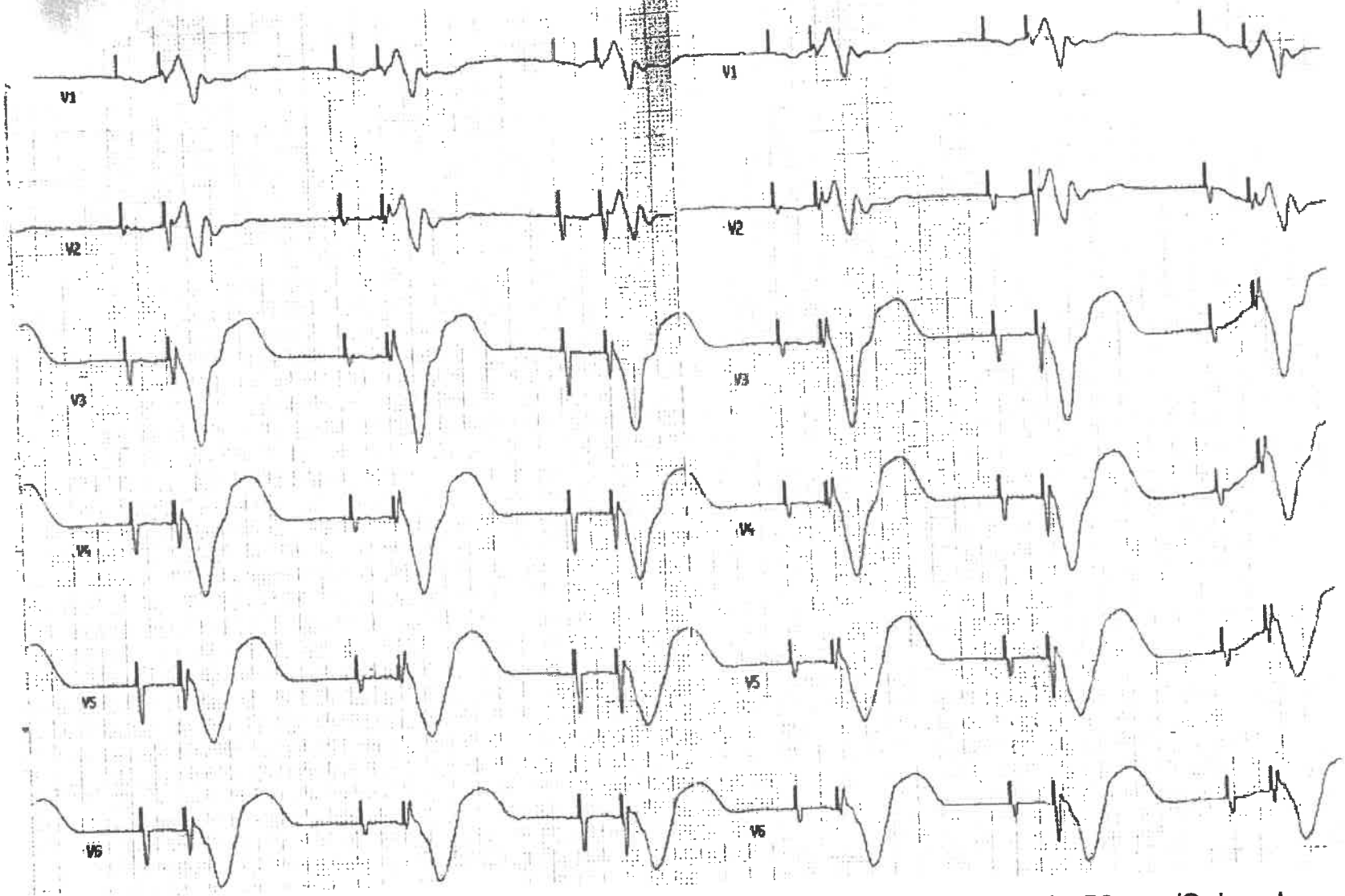
Papiervorschub: 50 mm/Sekunde

Beispiel-EKG 10.1



Papiervorschub: 50 mm/Sekunde

Beispiel-EKG 10.2



Papiervorschub: 50 mm/Sekunde

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