SELF-INSTRUCTION

Wolff-Parkinson-White Syndrome: Generalities

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Instructions

In programmed instruction, the student builds a structure of knowledge in steps. These steps are small units of information called frames. Most of the frames in this program ask you to do something—write a word, make a check mark, or fill in a blank. Immediately after writing a response, compare it with the correct answer on the right. A correct response is immediately confirmed and the point just learned is reinforced. If the answer is incorrect, you can determine immediately why the response was wrong. This eliminates the possibility of building knowledge on a faulty structure.

Cover the answers in the right hand column. After each response, remove the cover to expose the correct answer. Be careful not to expose the next answer.

In writing this program, the authors have presupposed that the clinician taking the course has an advanced level of knowledge in electrocardiography.

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The description which follows refers to that form of ventricular pre-excitation known as Wolff-Parkinson-White (WPW) syndrome in which the ventricles can be activated persistently or intermittently through an accessory A-V pathway and through the normal A-V pathway.

In classic WPW syndrome (either A or B)

The P-R interval is usually short (120 msec or less).

An initial delay (delta part of the QRS loop) is present.

The QRS loop equals or exceeds 120 msec.

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For didactic reasons, the electrical impulse is assumed to be transmitted from atria to ventricles at a faster speed through the accessory pathway than through the normal A-V pathway.

Therefore, the P-R interval should be shorter than normal. The impulse usually arrives at an ectopic ventricular site, thereafter propagating through ordinary ventricular fibers.

Ordinary ventricular fibers conduct slower than Purkinje fibers. Therefore, the initial QRS vector will be inscribed at a slower speed than normal. The terminal, nondelayed, part of the QRS loop indicates that parts of the ventricles are activated by the impulse descending through the normal A-V pathway.

The description of WPW syndrome given above corresponds to that of a "fusion" QRS loop in which parts of the ventricles are activated through the accessory and parts of the normal pathway.

When this occurs, catheter recordings from the specialized (intraventricular) conducting system show that the His bundle is activated after the onset of ventricular depolarization.

A "fusion" WPW beat means that:

- The ventricles are activated through two separate pathways.
- The H deflection appears after the onset of ventricular depolarization.

This initial delay is the most important vectorcardiographic aspect of WPW because the short P-R interval is not seen in the planar projections. The area of initial pre-excitation depends on the ventricular end of the accessory A-V bypass. This exit can be located in different parts of the ventricles and is responsible for the various types of intraventricular conduction patterns seen in WPW.

The direction of the maximal QRS vector can be abnormal. This depends on the form of ventricular activation secondary to the anomalous ventricular entrance.

Secondary ST-T changes are seen in WPW, as in every instance in which there is a primary change in depolarization.
WPW type A and WPW type B

Electrocardiograms from patients with WPW syndrome can be classified as type A or B according to the polarity of the delta wave and the RS ratio in lead V1.

In which plane (horizontal or frontal) will these changes be reflected?

In WPW type A, the accessory bundle ends, usually, in the posterior wall of the left ventricle.

The electrical forces produced by the impulse emerging from the accessory bundle will produce the part of the QRS loop.

WPW type A

Is the delta wave positive in lead V1? .........
Is the R larger than the S in lead V1? .........
Is this WPW type A? .........

WPW type B

In WPW type B, the accessory bundle ends in the right ventricle.

If the accessory bundle ends in the anterior portions of the right septal surface, the initial delay will be oriented to the left, posteriorly towards the left ventricles.
WPW type B with anterior entrance of accessory bundle

Is initial delay positive in lead $V_1$? . . . . . . . .

Is the $S$ wave larger than the $R$ wave in $V_1$? . . . . . . . .

Is this WPW type B? . . . . . . . .

Is initial delay positive in lead $V_1$? . . . . . . . .

Is the $S$ wave larger than the $R$ wave in $V_1$? . . . . . . . .

Is this WPW type B? . . . . . . . .

WPW type B with posterior entrance of accessory bundle

If the accessory bundle ends in the more posterior regions of the right ventricle, the initial delay will have a different orientation from the diagram in frame 8.

Is the initial delay positive in lead $V_1$? . . . . . . . .

Is the $R$ wave larger than the $S$ in $V_1$? . . . . . . . .

Is this WPW type A? . . . . . . . .
Is the delta wave positive in $V_2$, . . . . .
and is the R larger than the S in this lead? . . . . .

Go back to frame 8 and observe whether with an anterior entrance of the accessory bundle, lead $V_2$ showed a positive delta wave. . . . .

Differences between WPW type A and the two forms of WPW type B (horizontal plane)

**TYPE A**

\[ V_1 = \text{positive} \]
\[ V_2 = \text{positive} \]
\[ V_6 = \text{positive} \]

**TYPE B**

\[ V_1 = \text{negative} \]
\[ V_2 = \text{negative} \]
\[ V_6 = \text{positive} \]

Let us represent the initial delay in the horizontal plane as applied to three unipolar chest leads ($V_1$, $V_2$ and $V_6$) according to the laws of deviation. $V_6$ will always be positive because the initial delays point to the . . . .

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Polarity in unipolar leads

Fill in the blanks with + (positive) or − (negative)

<table>
<thead>
<tr>
<th></th>
<th>$V_1$</th>
<th>$V_2$</th>
<th>$V_6$</th>
</tr>
</thead>
<tbody>
<tr>
<td>WPW type A</td>
<td>(......)</td>
<td>(......)</td>
<td>(......)</td>
</tr>
<tr>
<td>WPW type B with anterior entrance</td>
<td>(......)</td>
<td>(......)</td>
<td>(......)</td>
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</tbody>
</table>
WPW type B
with posterior entrance

STUDY OF WPW SYNDROME WITH THE COMBINED USE OF VECTORCARDIOGRAPHY (HORIZONTAL PLANE QRS LOOP) AND HIS BUNDLE ELECTROGRAMS DURING ATRIAL PACING

His bundle recordings

Recording the electrical activity of the ventricular specialized conducting system permits the subdivision of the P-R interval into two major intervals: the A-H interval and the H-V interval.

A = atrial electrogram from the low right atrium
H = His bundle electrogram
V = onset of QRS complex in whichever lead (intracardiac or surface) it occurs first.

Significance of A-H and H-V interval

In its journey to the ventricles the atrial impulse first traverses the A-V node and later the ventricular specialized conducting system.

Therefore, the A deflection is followed by the ....... deflection which in turn precedes at a given (normal) interval the onset of ventricular depolarization (V).

Normally the atrial impulse reaches the His bundle before the ventricles.

A-H interval = A-V nodal conduction time.
H-V interval = conduction time through the ventricular specialized conducting system.

Which is inscribed first the ....... H or the ....... V?

In the absence of WPW syndrome (that is, in beats with exclusive conduction through the normal A-V pathway), atrial pacing at increasing atrial rates produces a prolongation of the P-R interval at the expense of the A-H interval (A-V node conduction time).

Atrial stimulation at increasing atrial rates produces a lengthening of the ....... interval at the expense of the ....... interval.

The A-H interval represents A-V ....... conduction time.
The morphology of the QRS loop does not change.

Which comes first, the H or the V?
Effects of atrial pacing in WPW syndrome

Let us see what happened in a patient with WPW syndrome in whom, during sinus rhythm, A-V conduction occurred through the normal pathway as well as through the accessory pathway. This combined A-V conduction pattern resulted in a "fusion" QRS complex.

a) During sinus rhythm the QRS complexes were "fusion" complexes in which the ventricles were activated partly through the normal pathway and partly through the accessory pathway.

b) Thus, the P-R interval was short, wide and the QRS complexes were normal accessory.

c) The short P-R interval gave a rough measurement of conduction time through the accessory pathway.

d) In this patient atrial stimulation at increasing rates did not prolong the P-R interval because this procedure does not affect conduction time through the accessory pathway.

e) However, atrial pacing caused a lengthening of the A-H interval (A-V node conduction time), as in patients without WPW syndrome.

f) Thus, the impulse was delayed at the A-V node while conducted at the same (fast) speed through the accessory pathway. The P-R interval remained short, while the A-H interval became prolonged.

g) Because of the latter (f) the impulse traversing the accessory pathway contributed more to ventricular activation than before any delay at the A-V node occurred.

As mentioned previously (frames 15a and 15b) atrial pacing at increasing rates did not change the interval, but prolonged the interval.

Therefore, the H deflection (representing the moment at which the His bundle is activated) was inscribed progressively later until it appeared after the beginning of ventricular depolarization.

Inscription of the forward H deflection after the beginning of the depolarization indicates that the supraventricular impulse reached the ventricles (through the normal pathway) before it reached the His bundle (through the accessory pathway).

Normally, which is inscribed first, the H or the V?

In beats without WPW conduction the H deflection is inscribed before the V.

Will the QRS loop show any delay?

In beats with WPW conduction the H deflection can be inscribed after the beginning of the ventricular depolarization.
"Fusion" beat in WPW type A

WPW type A produces anterior and leftward orientation of the QRS loop if the ventricular end of the accessory pathway is the posterior part of the ventricles.

The characteristic delay (of the QRS loop) occurs in its initial part.

Location of the delays in WPW type A

A short P-R interval and an initial delay occurs in WPW syndrome when the ventricles are activated partly through the accessory pathway (producing the initial delay) and partly through the normal A-V pathway (producing the nondelayed rest of the QRS loop). The H deflection can be inscribed after the V.

This results in the classic fusion QRS loop.

A short P-R interval and delays extending beyond the initial part of the QRS loop suggest that the ventricles are activated exclusively (or predominantly) through the accessory pathway.

When this occurs the His bundle deflection will still be inscribed before/after the onset of ventricular depolarization.

However, in the absence of WPW syndrome the His bundle deflection is inscribed before/after the onset of the QRS complex.

Let us now describe the changes seen in a patient with intermittent WPW type A who showed the following (progressive) A-V conduction patterns:

Exclusive normal A-V pathway conduction, with ventricular activation as an exclusive function of the impulse traversing the normal A-V pathway.

"Fusion" WPW beat resulting from ventricular activation through accessory and normal A-V pathways.

Exclusive accessory A-V pathway conduction, with ventricular activation as an exclusive function of the impulse conducted through the accessory pathway.
QRS loop resulting from exclusive normal A-V pathway conduction

The loop (does not) show any area of delay.
The corresponding P-R interval was normal.
The simultaneously recorded His bundle deflection was inscribed at its normal time, before the beginning of the QRS complex.

"Fusion" QRS loop resulting from A-V conduction through both normal and accessory pathways in a patient with WPW type A

The loops shows an initial delay.
The initial delay points anteriorly and to the left.
The major part of the loop is located anteriorly.
The corresponding P-R interval was short.
The His bundle deflection was inscribed the beginning of the QRS complex.

QRS loop resulting from exclusive accessory pathway conduction in a patient with WPW type A

The delays in the loop extend beyond its initial portions.
The major part of the loop is oriented anteriorly.
In this loop the terminal rightward oriented delay was NOT due to right bundle branch block but was an expression of the ventricular activation process occurring when an impulse propagates from a posterior left ventricular region.
The corresponding P-R interval was short.
This His bundle deflection was inscribed the beginning of the QRS complex.
Resemblance between QRS loops resulting from exclusive accessory pathway conduction (WPW type A) and from impulse formation at the posterior left ventricular wall.

The right sided loop resulted from impulse formation at (pacing from) the posterior left ventricular wall.

Note similarities in orientation, rotation and delays of the delays.

The general characteristic of the loops is specific for impulses propagating from the posterior left ventricular wall, regardless of whether the impulse reached this region through an accessory pathway (from the atria), or whether it originated there (ectopic ventricular beat).

A “fusion” beat occurs on the left sided schematic because the ventricles are activated from the accessory pathway (black dot), both divisions of the left branch (open circles on the left ventricular endocardium) and right branch (open circle on the ventricular endocardium).

A “fusion” beat occurs in the second schematic because the ventricles are activated from the accessory pathway (black dot) from the anterosuperior division of the bundle and from the branch.

A “fusion” beat occurs in the third schematic because the ventricles are activated from the accessory pathway and from the branch.

A “fusion” beat does not occur in the right sided schematic because the ventricles are depolarized exclusively from the accessory pathway. Therefore, when the activation fronts emerging from both divisions of the left bundle and from the right branch reach the first ventricular sites that they would normally activate, they find that these areas have already been made refractory by the impulse propagating from the pre-excited area.

When this occurs the QRS loop shows diffuse delays.
Let us now describe the changes occurring in a patient with WPW type A who showed the following A-V conduction patterns:

A-V conduction exclusively through the normal A-V pathway, but with RBBB.

"Fusion" complex resulting from A-V conduction through accessory pathway and through a normal pathway but with RBBB.

A-V conduction exclusively through an accessory pathway.

QRS loop resulting from exclusive A-V conduction through the normal pathway (with RBBB)

The loops shows a . . . . . . delay oriented . . . . . . . . . and to the . . . . . .

The corresponding P-R interval was . . . . . .

The simultaneously recorded His bundle deflection was inscribed at its normal time, . . . . . . the beginning of the QRS complex.

"Fusion" QRS loop resulting from A-V conduction through accessory pathway and through normal pathway with RBBB in a patient with WPW type A

In this case parts of the posterior portions of both ventricles are activated from the pre-excited site.

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The initial delay is produced by the impulse propagating from the pre-excited site.

a) The anterior part of the ventricle is activated by the impulse emerging from the divisions of the left branch.

b) The anterior part of the ventricle is activated by the impulse, which (after emerging from the divisions of the left branch) crossed the septum in a left-to-right direction.

c) Therefore, the terminal delay located anteriorly and to the was due to complete bundle branch block.

d) In addition, the P-R interval was, and the H deflection was inscribed the onset of ventricular depolarization.

QRS loop resulting from exclusive accessory pathway conduction in a patient with WPW type A who previously had normal A-V pathway conduction with RBBB

The terminal delays in this loop are not due to RBBB but are a consequence of the ventricular activation process specific for an impulse propagating from the posterior wall of the left ventricle.

Note that the terminal delay, although oriented, and to the as in RBBB, has a different location from the latter (compare this loop with that in frames 27 and 28).

In this beat the His bundle deflection must have been inscribed the beginning of the QRS complex.

Until when can a “fusion” beat occur in WPW syndrome resulting from A-V conduction through the accessory pathway and through the normal pathway with RBBB?

Assuming that there is “complete” right bundle branch block, a “fusion” beat failed to occur when the impulse propagating from the pre-excited area reached any of the sites first depolarized from the divisions of the left branch ahead of the activation front propagating through the latter.

However, in frame 28 a “fusion” beat does occur because the ventricles were depolarized from the accessory pathway and from both divisions of the left branch.
When was it easier for the impulse propagating from the accessory pathway to depolarize the totality of the ventricles, (...when WPW type A was associated with CRBBB) or (...when it was not)?

The explanation is that in WPW type A coexisting with CRBBB the impulse from the pre-excited area only had to reach the sites first depolarized from the left bundle, whereas in the absence of CRBBB it had to reach the sites first depolarized from BOTH left and right bundle branches.

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Let us now describe the changes occurring in a patient with intermittent WPW type B with anterior entrance who showed the following progressive A-V conduction patterns:

- Exclusive A-V conduction through the normal A-V pathway.
- "Fusion" beat resulting from A-V conduction through .......... pathways.
- Exclusive .......... pathway conduction.

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QRS loop resulting from exclusive normal A-V pathway conduction

Does the loop show any delay? ..........

Is the P-R interval short? ..........

Where was the H deflection inscribed? ..........

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"Fusion" QRS loop resulting from A-V conduction through both pathways in WPW type B with anterior entrance

The loop shows an .......... delay.

The initial delay points .......... and to the ..........

The major part of the loop is located posteriorly. (...true ...false)

The corresponding P-R interval is ..........

The H deflection is inscribed .......... the beginning of the .......... complex.
QRS loop resulting from exclusive accessory pathway conduction in WPW type B, with anterior entrance

The major part of the loop is located ......... and to the left.
The delays extend beyond the initial portions of the loop (......true ......false)
If a terminal delay is present, and if it is located posteriorly and to the .....,
it cannot be due to right bundle branch block.
The corresponding P-R interval was .........
The corresponding His bundle deflection was inscribed after the onset of ventricular depolarization. (......true ......false)

Can WPW type B coexist with “complete” RBBB?

WPW type B with a POSTERIOR entrance can be associated with CRBBB if the posterior parts of the ventricles are activated from the accessory pathway and both ventricles are depolarized from the divisions of the ......... branch.
In the loop shown above, the initial delay was due to ......... syndrome type B with a posterior entrance and the terminal delay was due to complete ......... bundle branch block.
However, as soon as the impulse from the accessory pathway reaches the left ventricular sites first depolarized from the left bundle, *ahead* of the impulse propagating from the latter, a "fusion" beat fails to occur.

Let us see what happens when WPW type B with an *anterior* entrance coexists with CRBBB.

A "fusion" beat occurs as long as the ventricles are depolarized from the accessory pathway and from the divisions of the left bundle. However, the (terminal) delay in right ventricular activation is abolished by the pre-excitation of the anterior part of the right ventricular free wall. Hence, the resulting QRS loop will be similar to that characteristic of WPW type B with an anterior entrance and *without* CRBBB. (Compare this with frame 34)

The diagnosis of simultaneous coexisting WPW type B and CRBBB is not possible in these instances.
The classification of WPW syndrome into type A and B is an oversimplification. The ventricular end of the accessory pathway could (theoretically at least) be located at any part of the tricuspid or mitral rings. Therefore, the results of endoepimyocardial mappings are more meaningful than an exclusively body surface electrocardiographic classification. We have attempted an extrapolation (to the vectorcardiogram) of the original ideas of Rosenbaum et al who divided their cases of WPW syndrome "depending on the form of the QRS in the leads from the right side of the precordium, particularly leads V1, V2 and V6 in two groups: A, in which R is the sole, or by far the largest deflection in all these leads and B, in which S or QS is the chief deflection in at least one of them."

Since if a QS deflection were to be present in only one of them the most likely lead would be V1, it seemed appropriate to assume (as we did) that the so-called type B could be subdivided into one with an anterior entrance (negative deflection in V1 and V2) and another with a posterior entrance (with QS in V1 and a positive deflection in V2 and V6).

But, as mentioned previously, the differences between type B with posterior entrance and type A are purely descriptive, intermediate forms do exist, and more important, a change from the former to the latter can be artfactually created at will by changing the position of chest lead V1 or of the recording chest leads of the Frank system.

Can CLBBB coexist with WPW type B?

With an ANTERIOR entrance, a diagnosis of this association cannot be made easily.

The left ventricle cannot be activated from the completely blocked branch.

As soon as the impulse from the accessory pathway reaches the sites first depolarized from the left branch ahead of the one traversing the latter, a "fusion" beat fails to occur.

Therefore, the ventricles will be activated exclusively from the path.

In WPW type B with a posterior entrance a "fusion" beat can occur until the impulse propagating from the pre-excited site reaches the areas first depolarized through the unblocked right branch ahead of the activation from traversing the latter.