The Pathogenesis of Atrioventricular Block in Coronary Disease

By Maurice Lev, M.D., Suman G. Kinare, M.D., and Alfred Pick, M.D.

SUMMARY

The hypothesis that the pathogenesis of acute and chronic atrioventricular (A-V) block in coronary disease is different is investigated. The conduction systems of two cases of acute A-V block and four cases of chronic A-V block associated with coronary disease were studied by serial section. This showed that acute blocks in coronary disease are related to ischemia. Chronic blocks, however, have a mechanical factor associated with the ischemic factor. The mechanical factor is related to the effect of fibrosis and calcification of the summit of the ventricular septum upon the branching portion of the A-V bundle and the left bundle branch.

Additional Indexing Words:
- Arteriosclerosis
- Atrioventricular bundle
- Conduction system
- Coronary disease
- Bundle of His
- Left bundle-branch fascicles

IT IS well known that acute atrioventricular (A-V) block in coronary disease is most often evanescent if the patient recovers. Despite this, chronic atrioventricular block due to ischemic heart disease is not rare. It seems, therefore, that the pathogenesis of the acute and chronic forms is different. The present work deals with the validity of this hypothesis.

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Methods

The hearts in two cases of acute atrioventricular block and four cases of chronic block associated with coronary artery disease were serially sectioned in a manner previously described. The technical details of the sectioning are included in table 1. The pathologic findings in the hearts, with the exception of those in the conduction system, are included in table 2.

Report of Cases

Case 1 (P.H.)

Clinical Summary

This elderly Negro male was admitted to the hospital on November 13, 1962, because of syncope while in bath. He was aphasic and kept clutching his chest. His pulse rate was at first 40, later 70. Blood pressure was first 40 systolic, later 120/80. The heart sounds were distant. Two days after admission a holosystolic murmur was heard radiating to the axilla. The course was progressively downhill with terminal pulmonary edema. He died on November 17, 1962.

Electrocardiographic Analysis

On the day of admission (fig. 1A) two records showed sinus rhythm with characteristic features and evolution of recent posterior wall infarct. Then on November 16 (fig. 1B) a 2:1 A-V block was noted. Partial A-V block at two levels was also present the next morning when atrial fibrillation had developed with a slow ventricular rate and ventricular pauses up to almost 3 sec.
The long R-R interval of 2.80 sec in the lower strip corresponded to the sum of two unequal cycles in the upper strip. This suggested that an advanced block in the upper A-V junction was associated with a period of A-V dissociation engendered by acceleration of A-V junctional impulse formation. The slow and irregular ventricular rate was the result of another region of block of second degree, type I, located in the lower part of the A-V junction, below the site of the junctional pacemaker. In the afternoon of the same day, the rhythm changed to atrial flutter with a persistent 2:1 ventricular response, suggesting regression of the A-V conduction disturbance. These varying atrial arrhythmias suggested involvement of the atria by the recent infarction.

**General Pathologic Findings in the Heart**

This was a case of arteriosclerotic narrowing of the three main coronary arteries with acute posteroseptal infarction. (For details see Table 2.)

**Pathologic Findings in the Conduction System**

**Sinoatrial (S-A) Node.** Focal fibroelastosis was present, with focal absence of nodal cells, and a focal infiltration of mononuclear cells.

**Approaches to S-A Node and A-V Node.** There was a fine infiltration of mononuclear cells with fibrosis and hemorrhage in the approaches to the S-A node. In the approaches to A-V node, a recent infarct of the lower approaches was present (fig. 2) with fibroelastosis. The fat tissue in the A-V nodal region showed necrosis with an infiltration of neutrophils and red cells. Arteriolar sclerosis was also in evidence.

**A-V Node.** In the periphery and in some areas inside of the node there was an infiltration of mononuclear cells and occasional neutrophils. In the distal part of the node there was focal degeneration of cells (fig. 3A).

**A-V Bundle.** In the penetrating portion, focal degeneration of cells with focal fibrosis was present (fig. 3B), and in the branching portion, a localized area of fibrosis was present at the junction of the bundle with the left bundle branch (LBB). There was also focal degeneration.

**LBB and RBB.** Slight acute degenerative changes were present in the LBB with infiltration of neutrophils throughout, and all parts of the right bundle branch (RBB) showed mild fibroelastosis and focal acute degeneration. The first part of the RBB in addition showed arteriosclerosis, and hemorrhage. The second and third parts showed occasional necrosis of a cell, surrounded by lymphocytes and neutrophils. The third part also showed slight fatty infiltration and fibrosis.

**Case 2 (O.W.)**

**Clinical Summary**

This 77-year-old Negro was admitted on April 25, 1968, at 4 p.m. with a history of sudden pain in the chest and weakness. He was in Cheyne-Stokes respiration; blood pressure was 90/60, and heart rate 50. A transvenous demand pacemaker was inserted within an hour. At 7 p.m. he developed ventricular fibrillation. Resuscitation attempts including D-C countershock were unsuccessful and he died.

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**Table 1**

*Technical Details of Sampling of the Conduction System*

<table>
<thead>
<tr>
<th>Case</th>
<th>S-A node &amp; approaches</th>
<th>A-V node &amp; approaches</th>
<th>A-V bundle, penetrating</th>
<th>A-V bundle, branching</th>
<th>LBB</th>
<th>RBB</th>
<th>Total no. of sections</th>
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<tr>
<td>1</td>
<td>q 10</td>
<td>Beginning q 20; later q 10</td>
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<td>q 10</td>
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<td>q 10</td>
<td>2,102</td>
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<td>2</td>
<td>q 10</td>
<td>q 10</td>
<td>q 10</td>
<td>q 10</td>
<td>Beginning q 10; later q 20</td>
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<td>6</td>
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<td>q 10</td>
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<td>q 10</td>
<td>q 10</td>
<td>q 10</td>
<td>1,707</td>
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</table>

Abbreviations: q 10 = every 10th section; q 20 = every 20th section.
### Table 2

**Pathologic Findings in the Heart**

<table>
<thead>
<tr>
<th>Case</th>
<th>Weight (g)</th>
<th>Hypertrophy &amp; enlargement</th>
<th>Coronary arteries</th>
<th>Myocardium</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>437</td>
<td>Hypertrophy of right atrium. Hypertrophy &amp; enlargement of all other chambers</td>
<td>Dominant right type. Arteriosclerotic narrowing of right ventricle, with superimposed thrombus. Anterior descending double branched. One branch markedly narrowed and calcified. Left circumflex narrowed throughout. Arteriosclerosis</td>
<td>Diffuse acute infarct involving posterior wall of both ventricles and posterior septum including the summit, superimposed on fibrosis; slight involvement of anterior wall. Recent infarct of right atrium. Rupture of septum</td>
</tr>
<tr>
<td>2</td>
<td>555</td>
<td>All chambers hypertrophied and enlarged</td>
<td>First portion of right coronary artery slightly narrowed by atherosclerosis. Markedly narrowed at acute margin. Anterior descending almost completely occluded by plaques close to origin. Half way down almost completely occluded again. Left circumflex at its beginning almost completely occluded by plaques. Arteriosclerosis</td>
<td>Old infarct of summit of ventricular septum, mostly on left side of septum extending to posterior and anterior walls. Recent infarct of summit of midseptum, and anterior septum, extending focally to anterior and posterior walls of left ventricle and slightly to inferior wall of right ventricle.</td>
</tr>
<tr>
<td>3</td>
<td>473</td>
<td>All chambers slightly hypertrophied and enlarged</td>
<td>Right main coronary generally narrowed by atherosclerosis on anterior wall of right ventricle. Left circumflex markedly narrowed by plaques and thrombus 2 cm from origin. Anterior descending considerably calcified and somewhat generally narrowed. Arteriosclerosis of conduction system</td>
<td>Recent and organizing infarct involving posterior and lateral wall and extending focally to anterior wall of left ventricle. Recent infarct extending in summit of ventricular septum. Calcification-in summit. Fatty infiltration of right atrium</td>
</tr>
<tr>
<td>4</td>
<td>475</td>
<td>Hypertrophy of both atria. Hypertrophy &amp; enlargement of right &amp; left ventricles</td>
<td>Main coronary arteries show minimal arteriosclerosis and no narrowing. Marked arteriosclerosis</td>
<td>Slight fibroelastosis of myocardium. Summit of ventricular septum shows marked fibrosis with small scars (see fig. 10)</td>
</tr>
<tr>
<td>5</td>
<td>522</td>
<td>Hypertrophy of right atrium. Hypertrophy &amp; enlargement of both ventricles</td>
<td>Right main coronary markedly narrowed by atherosclerosis over anterior wall of right ventricle. The left circumflex markedly narrowed close to its origin. First several cm of anterior descending occluded by old thrombus. Arteriosclerosis</td>
<td>Old infarct involving septum, especially summit, and posterior wall of left ventricle, with slight involvement of posterior wall of right ventricle</td>
</tr>
<tr>
<td>6</td>
<td>420</td>
<td>All chambers hypertrophied and enlarged</td>
<td>Dominant left coronary distribution. Right coronary not narrowed. Left anterior descending markedly narrowed by atherosclerosis 3 cm from origin. Left circumflex almost completely occluded just before giving off posterior descending. Arteriosclerosis</td>
<td>Recent and old infarct summit of ventricular septum and anterior and posterior papillary muscles. Focal acute degeneration throughout right and left ventricles</td>
</tr>
</tbody>
</table>
Figure 1

Case 1: Electrocardiograms. (A) Evolution of recent infarction of the posterior wall. (B) Subsequent electrocardiograms. (Upper strip) 2:1 block. (Middle strip) Partial A-V block at two levels with atrial fibrillation. (Lower strip) Atrial flutter with persistent 2:1 ventricular response.

Electrocardiographic Analysis

An electrocardiogram 4 years before admission (fig. 4, 6-2-64) showed sinus rhythm with normal A-V conduction and contour alterations suggestive of healed postero-inferior wall infarction. In the admission record (fig. 4, 4-25-68), there was complete A-V dissociation due to advanced, probably complete A-V block. The ventricular complexes had a pattern of a right bundle-branch block with left axis deviation to about -90° and evidence of recent anteroseptal infarction in the
precordial leads. The electrocardiographic location of the recent infarction suggested that the A-V block was caused by complete bilateral bundle-branch block.4

**General Pathologic Findings in the Heart**

This was a case of arteriosclerotic narrowing of the three main coronary arteries with old and recent anteroseptal infarction. (For details see table 2.)

**Pathologic Findings in the Conduction System**

**S-A Node.** Severe but not complete fatty separation of the node from the approaches was present. In the approaches to S-A node, there were distinct zones of fibrosis, with occasional zones of focal infarction in atrial appendage. Slight arteriolosclerosis was also present. In the approaches to A-V node, the superior approaches showed distinct fibrosis.

**A-V Node.** Focal zones of degeneration were present in the beginning with an increase in connective tissue.

**A-V Bundle.** In the penetrating portion moderate fibrosis with occasional arteriolosclerosis was present. In the branching portion there was diffuse acute degeneration, focal necrosis, edema, and hemorrhage (fig. 5A). Also present was a diffuse fine fibrosis.

**LBB.** The main bundle showed early necrosis with an infiltration of neutrophils as it lay adjacent to an acute infarct (fig. 5B).

**RBB.** The first part showed acute degeneration with slight fibrosis. Both processes were more marked in the second portion. The third part showed fibrosis, fatty infiltration, and an infiltration of neutrophils as it lay in an infarct of the moderator band.

**Case 3 (N.O.)**

**Clinical Summary**

This 71-year-old man with a history of previous "heart attacks" was admitted to the hospital on May 5, 1960, with left-sided chest pain and attacks of weakness and sweating, during which the pulse rate dropped from 90 to 38. There was an initial good response to isoproterenol, but one attack required artificial external pacing. The patient died in cardiac arrest on June 2, 1960, before an internal pacemaker could be implanted.

**Electrocardiographic Analysis**

The electrocardiogram showed a variety of disorders of impulse formation and conduction illustrated in figure 6A and B. Sinus rhythm with first degree A-V block and right bundle-branch block with left axis deviation to about −60° (fig. 6A, 4-8-59), changed later to complete A-V block with a slow, apparently right ventricular rhythm (fig. 6A, 1-17-60). Episodes of ventricular arrest

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Figure 2

Case 1: Approaches to the A-V node. Hematoxylin-eosin stain; reduced from × 150.
Case 1: (A) A-V node and approaches showing focal necrosis of the node, and a recent infarct of the approaches. (B) Branching portion of A-V bundle showing focal necrosis. (A and B) Hematoxylin-eosin stain; reduced from $\times$ 150. $A =$ approaches; $B =$ A-V bundle; $N =$ A-V node; $V =$ ventricular septum.
Case 2: Electrocardiograms. On 6-2-64 showing sinus rhythm with normal A-V conduction and suggesting healed posterior wall infarction; on 4-2-68 complete A-V dissociation due to advanced, probably complete, A-V block and evidence of recent anteroseptal infarction.

Figure 5
Case 2: (A) A-V bundle showing focal necrosis. Hematoxylin-eosin stain, reduced from × 150. (B) Left bundle branch showing recent infarct. Hematoxylin-eosin stain; reduced from × 150. B = bundle; LBB = left bundle branch; V = ventricular septum.

were attributable to two different mechanisms (fig. 6B); during sinus rhythm (P-R, 0.24 sec) there were periods of sinus arrest or S-A block leading to A-V junctional escape (12-3-59); during A-V block prolonged periods of ventricular standstill were caused by cessation of ventricular impulse formation (12-14-59). There was no definite evidence of ischemic heart disease. The left axis deviation at the time of right bundle-branch block suggested some additional lesion in

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Figure 6
Case 3: Electrocardiograms. (A) Left strip shows sinus rhythm with first degree A-V block and right bundle-branch block with left axis deviation. Right strip shows complete A-V block. (B) Upper strip shows intermittent sino-atrial block. Lower strip shows temporary ventricular arrest in complete A-V block. See text.

the anterior distribution of the left bundle branch and that the intermittent complete A-V block was the result of temporary complete bilateral bundle-branch block. Another unrelated cause of the
Case 3: Calcific mass compressing the branching portion of the A-V bundle. Weigert-van Gieson stain; reduced from $\times 90$. B = A-V bundle; C = calcific mass.

Syncopal attacks may have been degenerative or ischemic disease of the atrial tissue in or around the S-A node.

General Pathologic Findings in the Heart

This was a case of arteriosclerotic narrowing of the three main coronary arteries with organizing posterolateral infarction and recent posteroseptal and lateral infarction. (For details see table 2.)

Pathologic Findings in the Conduction System

S-A Node. There was marked but not complete isolation of this structure by fat tissue.

Approaches to S-A Node. Fibroelastosis of the myocardium was present, with a fine infiltration of macrophages and lymphoid cells.

Approaches to A-V Node. Fatty infiltration was apparent but there was no isolation of the A-V node. In addition, there was an infiltration of neutrophils and macrophages in the fat tissue with focal necrosis of cells. The inferior approaches showed some fibrosis. An occasional arteriole was thickened and narrowed.

Case 3: (A) Beginning of LBB compressed by calcific mass. Hematoxylin-eosin stain; reduced from $\times 90$. (B) LBB more distally showing fatty infiltration and replacement. Weigert-van Gieson stain; reduced from $\times 150$. (C) RBB, second portion, showing replacement by fibrous and fatty tissue. Hematoxylin-eosin stain; reduced from $\times 150$. Arrows point to RBB and LBB in various views.

A-V Node. There was slight infiltration with fat, elastosis, a proliferation of sheath cells, and a slight infiltration of mononuclear cells. The ramus septi fibrosi and some of the arterioles were narrowed.

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A-V Bundle. Although there was a hyalinized and calcified lesion in the central fibrous body adjacent to the bundle, the penetrating portion of the bundle showed only slight fatty infiltration. In the branching portion the calcified lesion, above described, compressed the bundle so that about three fourths of it was destroyed (fig. 7). What remained showed degenerative and necrotic changes, elastosis, and hemorrhage. In addition, there was fatty infiltration of the left side of the bundle and fibrosis of the right side.

LBB. Fibers at the junction of LBB with the bundle both posteriorly and anteriorly were either compressed or pinched off by the calcified mass above described (fig. 8). The remaining fibers showed eosinophilic degeneration, slight hemorrhage, atrophy, an occasional infiltration of mononuclear cells, fibroelastosis, arteriolosclerosis, and infiltration of fat. Fibers more distally showed fibroelastosis, infiltration of fat with a slight infiltration of mononuclear cells. Still more peripherally LBB was almost completely replaced by fat (fig. 8B). Here there was a remarkable paucity of Purkinje cells.

RBB. The first part in its beginning showed moderate fatty infiltration, slight fibroelastosis, and slight infiltration of mononuclear cells. More distally in the first part RBB was half replaced by fibroelastic tissue. The second part showed progressive replacement by fibroelastic tissue till the replacement was almost complete (fig. 8C), with acute degeneration of the remaining cells. The third part showed fibroelastosis with fatty infiltration.

Case 4 (H.L.)

Clinical Summary

This 71-year-old man was first admitted in 1954 for dizziness, which was diagnosed as Stokes-Adams syndrome and treated with ephedrine. He was readmitted on May 2, 1958, for recurrence of these attacks, combined with shortness of breath and congestive heart failure. He improved on treatment with digitalis, diuretics, and isoproterenol. Drip until June 6 when sudden convulsions developed, and he died in cardiac arrest on June 7.

Electrocardiographic Analysis

The electrocardiograms (fig. 9) varied between sinus rhythm with a normal P-R and right bundle-branch block (fig. 9, 9-24-54) and complete A-V block. When the latter became permanent in 1958, the ventricular beats varied in rate and contour, between the patterns of left and right bundle-branch block, both with left axis deviation (fig. 9, 5-2 and 5-6-58). There was no definite evidence of myocardial infarction, but the left axis deviation (to about $-60^\circ$) during right bundle-branch block configuration together with a Q wave in $V_1$ was compatible with an old ischemic lesion in the anteroseptal area. The development of complete A-V dissociation from a right bundle-branch block suggested that the advanced A-V block in 1958 was the result of progressive bilateral bundle-branch block. The varying rate and shape of the ventricular beats at this time suggested that under isoproterenol

<table>
<thead>
<tr>
<th>H.L.</th>
<th>9-24-54</th>
<th>5-2-58</th>
<th>5-6-58</th>
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</thead>
<tbody>
<tr>
<td>I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>V1-6</td>
<td>5-36</td>
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</table>

Figure 9

Case 4: Electrocardiograms. (9-24-54) Sinus rhythm with normal P-R and right bundle-branch block. (5-2 and 5-6) Complete A-V block with contour of ventricular beats varying between the patterns of left and right bundle-branch block both with left axis deviation.
medication the spontaneous ventricular pacemaker shifted from one in the right bundle branch to another in the posterior fascicle of the left bundle branch, both located distally to the blocking lesions.

General Pathologic Findings in the Heart
This was a case of noninvolvement of the main coronary arteries but arteriolsclerosis was diffuse. The summit of the ventricular septum showed marked fibrosis with small scars (fig. 10). (For details see table 2.)

Pathologic Findings in the Conduction System
S-A Node and Approaches. There were no changes.

Approaches to A-V Node. Marked fatty infiltration, with no isolation of the A-V node, and slight to moderate fibrosis, with occasional infiltration of mononuclear cells, were present. Occasional arterioles showed marked narrowing.

A-V Node. There was slight fibroelastosis with an occasional infiltration of mononuclear cells.

A-V Bundle. There were no changes in the penetrating portion of the A-V bundle. In the branching portion an interruptive fibroelastic lesion, in spots partial and in spots complete, existed at the junction of the A-V bundle with LBB. The right side of the bundle showed fatty infiltration with moderate fibrosis (fig. 11A). An occasional arteriole was thickened.

LBB. Just distal to the junction of LBB with the bundle both posteriorly and anteriorly, there was fibrosis with destruction of about three fourths of the LBB (fig. 11B). Still more distally there was fibrosis with about 50% replacement, with mononuclear cell infiltration and foci of necrosis. There was a death of Purkinje cells in the periphery, and some of these cells showed degenerative changes.

RBB. The first part of RBB showed moderate fibrosis. At the junction of the first and second parts there was complete replacement by fibroelastic tissue (fig 11C). The remainder of the second part showed about 50% replacement. The third part was infiltrated with fat tissue.

Case 5 (H.B.)
Clinical Summary
This 64-year-old diabetic was admitted to the hospital on May 16, 1962, because of syncopal attacks. He had had previous admissions from 1957 to 1961 for congestive heart failure, treated by digitalis and diuretics. He also had peripheral vascular disease treated by sympathectomy and amputation of the left lower extremity. However, he had no angina. He was treated by intravenous isoproterenol drip, but he had several further syncopal attacks. His terminal episode on May 22, was one of ventricular fibrillation, in which d-c countershock was to no avail. He died on May 23, 1962.

Electrocardiographic Analysis
Between 1957 and 1961 all electrocardiograms showed sinus rhythm with a normal P-R interval, and right bundle-branch block with marked right axis deviation, exemplified in figure 12 on 9-1-60. In 1962, a complete A-V block had developed. The ventricular complexes varied between the previously noted configuration of the right bundle-branch block (fig. 12, 5-17 and 5-22) and one of the left bundle-branch block (5-18). The marked deviation of the QRS axis to the right (to about +150°) associated with right bundle-branch block pattern suggested an additional conduction defect in the posterior distribution of the left bundle branch, possibly on an ischemic basis. Thus the ventricular pacemaker on 5-17 and 5-22 was probably in the A-V junction, whereas on 5-18 the isoproterenol drip transiently accelerated a ventricular center located in the right bundle branch.
General Pathologic Findings in the Heart

This was a case of narrowing of the three main coronary arteries with old posteroseptal infarction. (For details see table 2.)

Pathologic Findings in the Conduction System

S-A Node and Approaches. There were no changes in the S-A node. In the approaches, distinct fibroelastosis was present, with slight arteriolosclerosis, and some acute degeneration of cells.

Approaches to A-V Node. There was moderate fibroelastosis with some acute degeneration of cells. The fat tissue showed arteriolosclerosis.

A-V Node. Distinct arteriolosclerosis was present, with slight fibrosis, and focal zones of acute degeneration of A-V nodal cells. At the end of the A-V node there was a form of degeneration of cells in which vacuoles containing round or oval variously sized bodies were noted.

A-V Bundle. In the penetrating portion, there was slight diffuse fibrosis. Cells with degenerative changes similar to those in the node were present. In the branching portion, this portion of the bundle lay on the right side and showed moderate diffuse fibrosis (fig. 13A). Cellular changes similar to those described in the node were present.

LBB. LBB was somewhat pinched off as it went over the hump of the septum to the left side both posteriorly and anteriorly (fig. 13A). Here it showed distinct fibrosis. More peripherally it showed slight to moderate fibrosis (fig. 13B) and fatty infiltration. There were also acute degenerative and vacuolar changes with a focal infiltration of mononuclear cells. The peripheral Purkinje cells appeared normal.

RBB. The first part presented slight to moderate fibrosis. At the junction of the first and the second part this involved replacement of one half to three quarters of this branch. The same type of degeneration of cells described in the node and bundle was present here. The beginning of the second part was almost completely replaced, and the middle portion was completely replaced by fibroelastic tissue (fig. 13C). The third part was likewise almost completely replaced by fibroelastic tissue.

Case 6 (F.S.)

Clinical Summary

This 59-year-old man had a history of myocardial infarction in 1952 and 1957. His first syncopal attacks occurred in 1961. An epicardial left ventricular pacemaker was implanted in another hospital. On December 29, 1961, he was
admitted because of pacemaker malfunction. He was maintained on isoproterenol drip until January 20 when syncopal attacks developed. One of these caused by ventricular arrest changed to ventricular fibrillation. He was resuscitated by defibrillation but died 24 hours later, on January 21, 1962, with progressive cyanosis and hypotension.

**Electrocardiographic Analysis**

Several electrocardiograms in 1957 showed sinus rhythm with a normal A-V conduction, and right bundle-branch block with frontal axis at about $-30^\circ$ (fig. 14, upper record). Some showed T-wave alterations suggestive of transitory ischemia of the anterior wall. All later records showed complete A-V block. At first the ventricular complexes were regular responses to an implanted left ventricular pacemaker (except for a few spontaneous, usually interpolated premature ones, fig. 14, lower record). Later (not illustrated) pacer discharges and ventricular responses became irregular and eventually ceased. Spontaneous slow idioventricular complexes
emerged, varying in shape and rate, probably originating in two ventricular centers.

**General Pathologic Findings in the Heart**

This was a case of narrowing of the anterior descending and circumflex of a dominant left coronary artery system, with recent and old infarction of the summit of the ventricular septum. (For details see table 2.)

**Pathologic Findings in the Conduction System**

*S-A Node.* There were no changes.

**Approaches to S-A and A-V Nodes.** Focal acute degeneration of muscle cells was present with occasional arteriolosclerosis.

*A-V Node.* Focal acute degeneration of muscle cells was present.

*A-V Bundle.* In the penetrating portion of the bundle there was slight fibroelastosis. In the branching portion, focal necrosis was present; it was more marked at the junction of LBB. Moderate fibroelastosis, with distinct arteriolosclerosis was noted.

*LBB.* There was distinct fibroelastosis with replacement of about one half of the main bundle—both posteriorly and anteriorly. More peripherally there was almost complete replacement of LBB in areas, and in others fibrosis with acute degenerative changes.

**RBB.** The first part which was intramuscular showed moderate to marked fibrotic involvement of one half to three quarters of its extent. The second part was markedly replaced by fibroelastic tissue. The remaining cells showed marked degeneration with an infiltration of mononuclear cells. The third part showed considerable fibroelastosis with acute degeneration of remaining cells and a slight infiltration of mononuclear cells.

**Discussion**

In our series there are two cases of acute atrioventricular block associated with acute myocardial infarction and four cases of chronic block associated with chronic coronary ischemia. The coronary ischemia in five of the six cases is evidenced by the marked narrowing or occlusion of the three main coronary arteries or of the two main coronary branches of a dominant left coronary associated with arteriolosclerosis. In the sixth case, there was only arteriolosclerosis with no narrowing of the main branches. The combination of main artery and arteriolar involvement may be regarded as more severe than...
**A-V BLOCK IN CORONARY DISEASE**

### Figure 14

**Case 6. Electrocardiograms. (8-19-57) Sinus rhythm with normal A-V conduction and RBBB. (6-17-61) Shows complete A-V dissociation in advanced A-V block.**

<table>
<thead>
<tr>
<th>Date</th>
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<tr>
<td>8-19-57</td>
<td>I-III, V1-3-6</td>
</tr>
<tr>
<td>6-17-61</td>
<td>I, II, III, V1-6</td>
</tr>
</tbody>
</table>

Main artery involvement alone, for the arterioles are the final pathway of nourishment before the capillaries, and their involvement may vitiate any recourse to action of anastomoses. The case of arteriosclerosis alone is relatively uncommon, is unassociated with arteriolar disease elsewhere, and has been previously documented as being related to conduction disturbances by Yater and associates, and Lenègre. We have no evidence, however, that it is as common an isolated cause of chronic A-V block as indicated by Knieriem and Ebert. Thus, all six cases in this series have a factor of ischemia in the causation of the A-V block.

There is a difference, however, in the findings in the conduction system in the blocks associated with acute infarction and the blocks associated with chronic coronary ischemia. The acute blocks are apparently purely ischemic in origin. The acute block in case 1 was associated with a recent posteroseptal infarction. The conduction system showed necrosis of the approaches to the A-V node and focal degeneration or necrosis of the A-V node, bundle, and bundle branches. It is difficult to say from the histologic standpoint which part of the conduction system is responsible for the block. Judging by the severity of the lesion (and the electrocardiograms) it would appear that the block was due to the involvement of the approaches to the A-V node. The acute block in case 2 is accompanied by a massive recent anterior and
mid-septal infarction. The conduction system shows necrosis, hemorrhage, and edema of the branching portion of the A-V bundle and the main part of the left bundle branch with focal involvement of the right bundle branch, and the approaches to the A-V node, the A-V node itself, and the penetrating portion of the bundle. The block, therefore, is probably related to the pathology of the branching portion of the A-V bundle and left bundle branch. This difference in the involvement of the conduction system in posteroseptal versus anteroseptal infarction corresponds to the findings of Blondeau and associates\(^9\) and Davies.\(^10\) This difference is also mirrored in the electrocardiographic aspect as pointed out by Langendorf and Pick,\(^4\) Sutton and Davies,\(^11\) Friedberg and associates,\(^12\) and Norris.\(^13\)

In the pathogenesis of the chronic block in the other four cases, in addition to ischemia, there is a suggestion of a mechanical factor. These cases show calcification, fibrosis with small scars, or an old infarct of the summit of the ventricular septum, or a branching portion of the A-V bundle present on the right side, with the left bundle branch given off over the hump of the septum. Thus, the left bundle branch in these cases is very likely affected mechanically by the adjoining pathologic state as well as ischemically, while the changes in the branching portion of the bundle and the right bundle branch are probably ischemic in origin. The possible role of the summit of the ventricular septum in the pathogenesis of conduction system lesions has previously been alluded to in left bundle-branch block\(^14\) and in myocarditis.\(^15\)

The above findings of the involvement of the distal part of the A-V conduction system in chronic A-V block in coronary disease corresponds to the clinical data. From the electrocardiographic standpoint this has been considered to be due to the involvement of the branching bundle, or the bundle branches or of both, and often has been heralded by bundle-branch block of various types,\(^7, 13, 16, 17\) as in some of our cases. We may postulate that the irregular involvement of the branching portion of the bundle and the bundle branches, both by ischemia and mechanical injury produced by fibrosis or old infarction of the summit of the ventricular septum, produces, in the beginning, right or left bundle-branch block, or the former combined with an anterior or posterior "hemiblock,"\(^18\) and subsequently, complete bilateral bundle-branch block, manifested in the electrocardiogram as complete A-V block.

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References


Circulation, Volume XLII, September 1970
17. LASSER RP, HAFT JI, FRIEDBERG CK: Relationship of right bundle-branch block and marked left axis deviation (with left parietal or peri-infarction block) to complete heart block and syncope. Circulation 37: 429, 1968

Role of Research in Medical Education

...research serves additional vital functions in the education of physicians. In a field in which content changes so fast that what one learns in school is at best a foundation for the medicine of a decade later, it is important to have men capable of distinguishing assertion from evidence and dogma from adequately documented fact. Nothing fosters the development of the necessary critical ability to distinguish, as does an adequate experience in trying to develop evidence oneself, that is, in research. Such experience for every student of medicine is probably impossible, desirable as it might be. But it is absolutely essential as a part of the background of the teacher of medicine if he is to separate the relevant and probable from the mass of inevitably conflicting information and to transmit to his students the open-minded skepticism that will determine the adequacy of their future growth.

The Pathogenesis of Atrioventricular Block in Coronary Disease
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