A HISTOPATHOLOGICAL STUDY ON THE CONDUCTION SYSTEM OF THE SO-CALLED "POKKURI DISEASE"
(SUDDEN UNEXPECTED CARDIAC DEATH OF UNKNOWN ORIGIN IN JAPAN)

Koh Gotoh

The conduction system of seven cases died of the so-called "Pokkuri disease", was histopathologically studied with serial sectioning method.

Fibrosis with a significant reduction of conduction fibers was observed in the sinoatrial node and junction between the node and atrial muscle fibers in 6 cases. Abnormal course and branching of the sinus node artery was seen in 6 cases of which 3 had no penetration of its main branch into the node. Some pathological lesions existed in the atrioventricular conduction system in 4 cases: 2 had fibrotic lesion in the distal bundle of His and proximal left and right bundle branches which were sandwiched between the abnormal conal muscle and the summit of ventricular septum. Remaining 2 had lipomatous partial interruption in the mid- and distal bundle of His. Simultaneous involvement of sinoatrial node and the atrioventricular conduction system was observed in 4 cases. One of such cases showed abnormal ECG consisted of a left axis deviation and right bundle branch block.

As a conclusion, pathological lesions in the conduction system are revealed in more than half of cases of "Pokkuri disease". The pathogenesis seems to be related to minor anomalies such as abnormal sinus node artery, abnormal conal muscle situation.

A number of investigators including Yoshimura & Namiki, Yoshimura & Kobasli and Okudaira have reported on autopsied cases of what is called "Pokkuri disease", a clinical entity also referred to as acute heart failure or unexplained sudden death.

Autopsy findings of this disease entity are characterized by absence of any major lesions directly accountable for death of the patient in most cases. At present, the diagnosis is based on the specific circumstances under which the patient dies from what cannot be identified by autopsy.

According to Yoshimura et al, fatalities with the following general characteristics have come to be grouped under the name of "Pokkuri disease" at the Tokyo Metropolitan Police Medical Institute: (1) A relatively young, constitutionally healthy man having led a normal life (2) died suddenly with a groan (3) while sleeping late at night (4) without any known factors precipitating cardiac arrest and (5) without any causes explainable in terms of autopsy findings.

Keywords:
Sinus node
Sinus node artery
Abnormal muscle bundle
U-shaped turn
Bundle of his
Pokkuri disease

(Received on August 20, 1975; Accepted on December 17, 1975)
The 2nd Department of Pathology, Showa University School of Medicine, Tokyo, Japan
(Director: Prof. Kouji Tashiro)

Japanese Circulation Journal Vol. 40, July 1976 753
Reported patho-morphological findings include the normal or slightly enlarged heart either in weight or in size, fragmentation and mild anoxia of the myocardium, developmental imbalance between the myocardium and vascular system, distribution of the coronary arteries of the right coronary preponderant type and slight degree of hypoplasia of the aortic system. Frequent findings of other organs so far documented comprise severe congestion of parenchymal organs, extravasation in mucosa, residual involuted thymus, diminished lipid content of the adrenal cortex, and degeneration of sympathetic ganglionic cells. The last of the above-listed changes was reported by Mukai.

The premortal ECG pattern of the patient with this disease remains largely to be elucidated, with the only exception of prolongation of PR segment in 1 case reported by Fukuda et al. Okudaira and associates have studied the architecture of the coronary arterial system by means of synthetic resin casts infused in the postmortal coronary arteries but failed to show decisive evidence in support of insufficient coronary circulation as the etiologic factor. One of the known causes for cardiogenic sudden death is arrhythmias such as ventricular fibrillation, heart block or ventricular arrest. Unexpectedly, there is no study thus far available as to the morphological features of the cardiac conduction system associated with the disease. This prompted us to undertake a morphological study of the system in the disease in an attempt to determine if any abnormality in the system was significantly contributory to the sudden death of the patient. Part of the results thus obtained were reported previously. In this report the pathological changes in the conduction system detected by us in 7 cases of this disease so far encountered are summarized with a view showing that conduction disturbances are not negligible factor underlying the illness and thereby providing a clue to the valid preventive measure to be taken against it.

**Subjects and Methods**

Seven patients aged 21-41, who were diagnosed as “Pokkuri disease” at the Showa University Hospital or the Tokyo Metropolitan Police Medical Institute, were used in this study. Close gross-observation of the autopsied hearts, fixed in formalin, confirmed that they were free of valvular heart disease, coronary artery disease or myocardial fibrosis.

Examination of the conduction system was done by Lev’s method; the sinus node including junctional part of the atrial internodal tracts and atrioventricular conduction system were cut out in 4 to 6 blocks, which were then embedded in paraffin to prepare 10,000-30,000 serial sections, each 8μ in thickness. A series of 5 or 10 sections were submitted at one time to observation under the light microscope after alternate staining with H. E. and Weigert-Van Gieson stain. Coronary vessels were examined by the ultra-soft X-ray technique with 75% barium sulfate injected into the coronary arteries at autopsy as well as by the histological method described above.

**Results**

Case 1 - A 27-year-old male, factory worker.

The patient had his right wrist-joint severed accidentally by a milling machine, with an approximately 4 cm portion of palmar skin left intact. About 30 minutes later he underwent re plantation of the right hand with the successful result that the function of the injured hand was almost completely restored. About 2 and a half months after admission he suddenly shouted at midnight. Rushing for his rescue, the nurse found his heart having already stopped beating. There was only 1 electrocardiogram of the patient available, which was taken premortally at the time of admission (Fig. 1). It showed sinus rhythm with left axis deviation of the QRS vector in over -30° and complete right bundle branch block. Chest X-ray film revealed no particular abnormalities (Fig. 2).

The heart weighed 280 g and was found neither enlarged nor hypertrophied. The tricuspid, pulmonary, mitral and aortic valves were all normal. There was no evidence of coronary arteriosclerosis. The distribution of the coronary arteries was of Schlesinger type I or the right preponderant type as shown by postmortem coronary arteriograms: the right coronary artery was seen supplying by far wider area than the left, i.e., 80% of the posterior surface of the left ventricle, while the left circumflex branch was poorly developed, barely covering the obtuse margin of the heart. The coronary arteriogram (Fig. 3) showed that the sinus node artery left the right coronary artery at its root, with its ascending branch not passing through but bypassing the sinus node, curving acutely just before reaching it (U-shaped turn phenomenon) and that the sinus node was supplied by several
Fig. 1. Sinus rhythm with left axis deviation of the QRS vector of over -30° and complete RBBB.

Fig. 2. No particular abnormalities of cardiac shadow.
Fig. 3. The sinus node artery leaves the right coronary artery at its root, with its ascending branch not passing through but by-passing the sinus node, as arrow shows, curving acutely just before reaching it. (U-shaped turn phenomenon).

In the sinus node which was normally located but was as small as a little less than 4 mm in length, there were degenerated, atrophied cells scattered over fibrotic adipose tissue with sparse surviving cells: 70% of the cells had been lost (Fig. 4). The junction of the sinus node with atrial muscle was intact, the fibrotic change involving no farther than the sinus node. The atrioventricular node was normal as the midportion of the bundle of His. The bundle of His was found entering the central fibrous body in a normal manner but distinctly abnormal below the midportion: an abnormal muscle bundle ap-
Histopathology of Conduction System of the “Pokkuri Disease”

Fig. 4. Degenerated, atrophied cells scattered over fibrotic adipose tissue with sparse surviving cells.

Case 2—A 41-year-old male, factory worker.
Being of sturdy build and constitutionally healthy, the patient died suddenly at midnight giving a few groans.
The heart of the patient weighed 300 g and was grossly normal. The anatomic pattern of the coronary arteries was of the right preponderant type, with the circumflex branch barely reaching the obtuse margin of the heart: Schlesinger type I and Spaltehorz type II.
The right coronary artery, after shooting of the sinus node artery from the main trunk, made a turn immediately before reaching the node to circumvent it (U-shaped turn phenomenon), with only its small branches supplying the node. The sinus node artery showed a moderate degree of atherosclerotic stenosis at one site, but coronary arteriosclerosis was generally mild. The sinus node was moderately fibrotic particularly at its junction with atrial muscle on the caudal side. The atrioventricular node was normal but, at the distal portion of the bundle of His near the origin of the left bundle branch, there was mild to moderate replacement of the conduction cells by adipose tissue (lipomatosis), with approximately 30% of the cells having been replaced (Fig. 7).

Case 3—A 32-year-old male, company employee.
Constitutionally healthy and sturdy build, the patient died suddenly at night giving a groan.

The heart of the patient weighed 300 g and showed no gross abnormalities. The distribution of the coronary arteries was of the right coronary predominant type: Schlesinger I and Spaltehorz II. There was coronary arteriosclerosis of mild degree, with only 3 loci of 25% stenosis at the root of the anterior descending branch. The sinus node artery was found arising from the right coronary artery, which was moderately fibrotic, was supplied by only small tributaries of the artery. As in case 2, the fibrotic change was marked at the junction with atrial muscle of the sinus node on its caudal side, resulting in loss of approximately 50% of the cells. The atrioventricular node was normal but, from near the mid- to distal portion of the bundle of His, there was an outgrowth of myocardial fibers originating from the conus in the upper ventricular septum, which appeared to hang over the atrioventricular conduction system from the right in such a way as if sandwiching it, although to a milder extent than in Case I (Fig. 8). Moderate fibrosis was also present in some portions of both the right and the left bundle branches.

Case 4—a 33-year-old male, bank employee.

Of mediocre physique, the patient had had a cold since about 2 days before. While being examined at a practitioner’s office, he suddenly lost his consciousness and then died despite all efforts for resuscitation.

The heart of the patient weighed 320 g. The anatomic pattern of the coronary arteries was of Schlesinger type I with a nearly balanced distribu-
Fig. 6. Complete interruption of the RBB by fibrosis.

Fig. 7. Mild to moderate replacement of the conduction cells by adipose tissue of the distal portion of the bundle of Hiss.
Fig. 8. Fibrosis is found in RBB. In this portion myocardial fibers hang over the RBB, as if sandwiching.

Fig. 9. Arrows show junction of the sinus node and atrial muscle. Prominent fibrosis is revealed in this portion.
Fig. 10. Sinus node shows generalized fibrosis of moderate degree. Two vessels are the branches of the sinus node artery.

...tion on both sides. No coronary arteriosclerosis was noted. After leaving the right coronary artery, the sinus node artery passed through the sinus node anteroposteriorly in an almost normal fashion, although acutely curving and arborizing. The sinus node was nearly normal in size but showed generalized fibrosis of moderate degree with approximately 30–40% of the cells having been lost. A similar change was observed at the junction of atrial muscle with the sinus node on its caudal side. The atroventricular conduction system was normal but had diminished conduction cells with the atrial muscle (periphery of the posterior internodal tract) detached from, although normally continuous with, the pathway on the cranial side due to an overgrowth of adipose tissue.

Case 5—A 21-year-old male, company director.

Having been under ambulatory care for neurosis at a university hospital, the patient groaned in a bed at about 9 a.m. Hastening to him, a member of his family found that he had no pulse but respiratory arrest.

The heart of the patient weighed 280g, a figure falling within normal limits, and showed no dilatation or hypertrophy of the atria or ventriculi. The anatomic pattern of the coronary arteries barely fell under Schlesinger type I, although close to the balanced type. No coronary arteriosclerosis was present. Taking origin from the right coronary artery, the sinus node artery passed around the left side of the superior vena cava before entering the sinus node at its caudal portion, where it trifurcated to course through the node posteroanteriorly. The sinus node was normal in size but with generalized fibrosis of moderate degree. Prominent fibrosis was present at the junction of the head of the sinus node with atrial muscle, where nearly 70% of the cells had been lost (Fig. 9).

Case 6—A 22-year-old male, factory worker.

Having drunk the night before, the patient succumbed at 3 a.m. giving a groan with his head thrown back.

His heart weighed 344 g and was normal in appearance. The distribution of the coronary arteries was of Schlesinger type I; there was no coronary arteriosclerosis. The larger branch of the sinus node artery arising from the left coronary artery (circumflex branch) was found anastomosed with the smaller one from the right coronary artery. One of the branches passed around the sinus node from the left and the
Fig. 11. A: The central portion of bundle of His.  
B: The midportion of bundle of His.  
C: The distal portion of bundle of His.  
A and B show prominent lipomatosis.

other from the right before gaining entrance to it at the anterior and posterior surface respectively as 2 vessels of essentially the same size (Fig. 10). The wall of sinus node artery was hypertrophied and fibrotic but there was no prominent narrowing of the lumen. The sinus node was normal in size but located extraordinarily posteriorly. It had generalized fibrosis of moderate degree with nearly 50% of the cells having been lost.

Case 7—A 35-year-old male, printer.

The patient lost his consciousness with a groan at 3 a.m. A seizure of convulsion supervened and shortly thereafter he died.

The heart of patient was moderately hypertrophied with a weight of 465 g. The left ventricle was enlarged and mildly thickened. The coronary arteries showed a distribution pattern of Schlesinger type II with no evidence of arteriosclerosis. The sinus node artery originated from the left coronary artery was divided into 2 branches, which passed around the superior vena cava, one from the left and the other from the right, and then entered the sinus node, one anteriorly and the other posteriorly. The sinus node was essentially normal, including its junction with atrial muscle. The atrioventricular node also was normal but there was marked fatty degeneration in the midportion of the bundle of His, with the resultant loss of 70% of the conduction in the midportion of the bundle of His, with the resultant loss of 70% of the conduction cells (Fig. 11).

The findings of the cardiac conduction system in the 7 cases illustrated above are summarized in Fig. 12. In 6 of 7 cases there was fibrosis of the sinus node, which was generalized in distribution particularly in Cases 1 and 6, leading to loss of more than half the sinus node cells. In 4 cases, marked fibrosis was present at the junction of the sinus node with atrial muscle, with the cells having been heavily damaged on the caudal side in 3 and on the cranial side in 1 case. Along with these changes in the sinus node and adjacent area of the pathway, aberrant courses of vessels supplying the sinus node also constituted a frequent finding. The sinus node artery was found originating of the right coronary artery in 5, at the left coronary artery (circumflex branch) in 1 and at both in 1 of the 7 cases, but, in 3 cases, the main branch made a U-shaped turn to circumvent the sinus node supplied by only its small offshoots. In the remaining 3 cases the artery spread into 2 or 3 branches to supply the node, entering it at its caudal side after, in 1 case, passing around the superior vena cava in the reverse direction or counterclockwise.

The atrioventricular node was normal in all cases, although in 1 of the 7 cases there was a distinct fall in the number of cells at its junction with atrial muscle. In 4 of the 7 cases of change was noted in the bundle of His and at the origin of the bundle branches: replacement of conduction cells by adipose tissue in 2 and hemiblock due to fibrosis in the other 2. In 2 cases an abnormal muscle bundle extending from the

*Japanese Circulation Journal Vol. 40, July 1976*
septum in the conus region appeared to put mechanical stress on the bundle of His and the bundle branches at their root, sandwiching them between it and the summit of the ventricular septum from above or from the right above.

**DISCUSSION**

Being common in Japan, “Pokkuri disease” strikes young men of robust health. It has been reported that men in their twenties account for 58% of the fatalities from the disease. The clinical manifestations and autopsy findings of the illness are peculiar and specific as discussed earlier. As to the causes of sudden death at large, Ohta\(^2\) and Fowler\(^9\) have placed emphasis on derangement of the conduction system. In fact, abrupt death comes from arrhythmias in many of the cases of ischemic heart disease, some of which have serious lesions in the conduction system including the sinus node. This induced us to undertake a study of the system in patients with “Pokkuri disease” on the assumption that arrhythmias might have somehow been involved in the occurrence of their death. Potentially lethal arrhythmias consist primarily of the so-called sick sinus syndrome\(^10\) which includes ventricular tachycardia, ventricular fibrillation, advanced atrioventricular block accompanied by Adams-Stokes attacks, ventricular arrest, sinus arrest and sinoatrial block. Block as a major component of the syndrome is said to correspond closely with morphological defects of the conduction system. When, therefore, a certain change is present in the system, the risk of death from arrhythmias for which the change is responsible must be considered to be high, even in the absence of premortal ECGs available.

In Case 1, an ECG fortunately taken immediately following injury showed left axis deviation and complete right bundle branch block, suggesting that the conduction in the right bundle branch and the anterior radiation of the LBB might have been interrupted at the time of ECG recording. The incidence of such ECG abnormalities in patients with “Pokkuri disease” remains still unknown because of unavailability of premortal ECG tracings in almost all instances. However, the fact that in the case cited above there was evidence of fibrosis induced complete or incomplete bilateral bundle branch block in association with myocardial abnormality in the conus region implies that sudden death of this patient might have somehow been related to what Rosenbaum\(^11-12\) designated trifascicular block. At the same time, the marked atrophy and degeneration of sinus node cells in this instance are ominous of sinus arrest which will readily develop in the presence of nocturnal vagotonia. Here it is quite likely that complicating trifascicular block should have kept the lower pacemaker system from regaining its automaticity, with the resultant ventricular arrest or fibrillation precipitating sudden death of the patient.

Such an analysis of Case 1 led us to the recognition that two factors, namely, pacemaker anomalies mainly involving the sinus node, and atrioventricular conduction defects possibly underline “Pokkuri disease”, a concept which provided a frame of reference in our assessment of the other cases.

It was found that not all but only 2 of the 7 patients exhibited pathologic changes in the sinus node which were serious enough to suggest sinus arrest. In other words, patients with such lesions there constituted a minority in the “Pokkuri disease”. On the other hand, a review of our series in the light of the recent statement of Okada\(^13\) that unbalanced fibrosis at the junctions of the sinus node with atrial muscle (internodal tracts) is an important factor in the genesis of the sick sinus syndrome including different types of arrhythmia of atrial origin disclosed that a majority or 4 of the 7 patients had a marked lesion at that junction. Of these, 3 had fibrosis on the caudal side or the proximal side of what James called the middle and posterior internodal tracts and 1 had fibrosis on the cranial side, that is, at the origin of the anterior internodal tract and the bundle of Bachmann. This indicates, among others, that an impulse spreading from the sinus node in a normal direction is intercepted at one of the junctions, leaving an unexcited region in the periphery. The resulting delayed entry of impulses from other normally excited areas may lead to a circus movement of excitation, which in turn will pave the way for supraventricular tachycardia, atrial flutter or fibrillation or, in the presence of excited vagus nerve, for sinoatrial block, all of which combined to make up the picture of the typical sick sinus syndrome. This is not a sheer imagination, because the unbalanced block at the junctions of the sinus node with atrial muscle has actually been demonstrated in some of our cases\(^14\) showing ECG evidence of this syndrome. Furthermore, the partial interruption at the junction of the head of the atrioventricular node with atrial muscle (posterior internodal tract), which was
noted in 1 of the 7 cases and which was shown by Okada et al.\textsuperscript{15} to give rise to incomplete atrioventricular block in cases of the systemic lupus erythematosus may possibly be among the etiologic factors for extreme bradycardia when it occurs in conjunction with a lesion in the sinus node and adjacent area.

The region extending from the distal portion of the bundle of His to the bundle branches represents the most predisposing site of the primary atrioventricular block. That a majority of 4 of 7 patients had a lesion in that area attests to AV block being of no minor significance as a possible cause of sudden death. Moreover, the coexistence of the above-mentioned lesions in the sinus node and adjacent area with atrioventricular conduction defects in 3 of these 4 cases necessarily leads us to the supposition that these 2 different types of aberration that concurred might have reduced the chance of resuscitation in nearly half the case. Considering the atypical fashion in which death occurred in the remaining 1 case, Case 7, it might reasonably be presumed that typical Pokkuri disease often result from a combination of an abnormality in the upper pacemaker system and block of the atrioventricular conduction system. Derangements of the conduction system, in terms of which it is obviously impossible to give a comprehensive account of the entire mechanism of the disorders underlying the manifestations of the illness, must nonetheless be regarded as playing a major role in the genesis of the disease, if they can be supposed to exist in not a minority but a majority of patients.

The pathogenetic process of such lesions in the conduction system is not easy to explain. To begin with, fibrosis of the sinus node is likely to occur not as a consequence of ischemia, but as a nearly physiological process with advancing age, since even the normal elderly will suffer fibrosis, which, intensified with age, will culminate in loss of nearly 50% of the cells. It is unreasonable, however, to ascribe conduction disturbances to cardiac connective tissue abnormalities in our series, which consisted exclusively of men younger than the middle-aged who should not show any degeneration of the tissue associated with aging. Secondly, the possibility exists that fibrosis did develop in the wake of a previous episode of myocarditis, which has been known to be occasionally insidious in onset or attended by no clinical manifestations. However, inflammation of the heart muscle leaving no vestige on the working muscle but a fibrotic lesion in the conduction system is quite improbable. Thus, two factors are left for us to consider: ischemia and endogenous degeneration of unknown origin.

The lesions in the coronary arteries in our 7 cases were too mild to warrant the inference that ischemia might be induced by ordinary arteriosclerotic coronary stenosis. Even the coronary arteriosclerosis of moderate degree seen in Case 2 was far milder than the 75% stenosis which give rise to ischemic changes. There was no significant stenosis of vessels passing across the epicardial surface in other 6 cases.

Noteworthy here is the abnormal way in which the sinus node artery courses. Normally the vessel arises from the main trunk of the right coronary artery in 60–90% of cases and from the left circumflex branch in the remaining. It passes through the middle of the sinus node as a branch which is relatively large for the size of the sinus node.\textsuperscript{16–17} In 3 of the 7 cases, by contrast, the artery was found making an acute U-shaped turn immediately before the node, with its main branch not gaining entrance to but only its arborizing small branches supplying the node. In other 3 cases the main branch was found entering the node as several offshoots into which it divided just before its entrance to the node.

Originally, the sinus node artery, because of its relatively large lumen, is considered not merely a nourishing vessel for the sinus node but part of a kind of receptor apparatus that serves the purpose of having abnormalities of pressure or blood flow within the artery reflected in pacemaker activity.\textsuperscript{16} Hence it is probable that abnormally preset reflective regulation by the autonomic nervous system is inherent in Pokkuri disease, which may be considered to be associated with the sinus node artery terminating in much smaller than normal branches in the sinus node which abounds in nerve endings.

In view of the fact that the structure of coronary vessel wall varies with the size of the lumen, just as the reaction of the wall in abnormal situations such as hypertension,\textsuperscript{18} the receptor apparatus being partly composed of arteries of varying lumen may involve the risk of causing fatal reactions in the sinus node, the pivot of circulatory regulation. Small arteries having circular smooth muscle cells in the media can be expected to respond to released catecholamine, for instance, in an apparently different manner from larger vessels such as the normal sinus node artery which has bidirectionally running smooth

\textit{Japanese Circulation Journal} \textit{Vol. 40, July 1976}
muscle cells in the media. It is likely enough that
the resulting spasm is much more intense in the
sinus node artery, which is extremely richer in
nerve endings, than in small arteries in the working
muscle, which are devoid thereof, and that,
as a consequence ischemia develops selectively in
the sinus node and adjacent area. Here the
characteristic anatomic pattern of the artery, i.e.,
less dense distribution in the perinodal region
including the nodal junction with the atrial
muscle than in the sinus node per se, may
provide a reasonable explanation of the more
marked ischemia and heavier cell damage at that
junction than in the sinus node in some cases.
Another circumstantial evidence is given by the
fact that in 3 cases in which there were promi-
} nent changes at the junction of the node on its
caudal side, the sinus node artery or its branches
were found entering the node at the cranial side,
whereas in 1 case with marked changes on the
cranial side of the junction the artery passed
around the superior vena cava counterclockwise
to enter the node at its caudal side: the side of
block due to fibrosis was at the periphery of the
branches of the artery in all instances. Still
another finding in support of the above-
mentioned hypothesis is that the intranodal
arteries in our series certainly had more
pronounced fibroelastosis in the intima and
media than vessels of the same size in other
region, making the impression that they had been
exhausted.

Let's turn to the possible causes of replace-
ment of some of the conduction cells by adipose
tissue. The artery taking origin posteriorly to
supply the atrioventricular node is as large as the
sinus node artery and has much nerve component
around it. The periphery of this artery, where it
arborizes, ordinarily corresponds with the mid-
to distal portion of the bundle of His, an area
which is favorable for the catecholamine or other
vasoactive substances to exert their effects. It
was in that region that there was an overgrowth
of adipose tissue. Accordingly, the high
incidence of concurrent lesions in the sinus node
and the atrioventricular conduction system could
be reasonably explained by assuming that
chronic recurrent ischemia was responsible. The
reason for the adjacent working muscle remain-
ing almost intact might reside in the fact that
autonomic nerve endings lie only in the conduc-
tion system. This hypothesis has two diffi-
culties:
(1) The question may well arise; Is spasm of
minor arteries enough to cause so serious damage
to the conduction cells, which are believed to be
more resistant to ischemic changes than working
muscle cells, as to result in their substantial loss?
(2) Sudden death at night of the patient as an
outstanding feature of Pokkuri disease reminds
one more naturally of a constitution vulnerable
to the vagotonic than the sympathicotonic state.

To the former question one can find an
answer by taking into consideration the possi-
bility of a substance cytotoxic to the conduc-
tion cells being released via a route other than
the vascular from a host of autonomic nerve
endings seen in the conduction system under the
light microscope. The latter difficulty can also
be overcome when one calls to his mind the
clinical fact that those who suffer from auto-
nomic imbalance can have hypersensitivity of
both the sympathetic and vagus nerves, while
supposing that the etiologic factors for chronic
disturbance of the conduction system are alien to
the mechanism of the sudden death.

After all, any hypothesis advanced to explain
the purely functional events in terms of the
established finding of fibrosis may well be some-
what short of satisfactory. It may be realistic
and wise to go no further than stating for the
time being that the so-called Pokkuri disease is
associated with lesions of unexplained origin in
the cardiac conduction system.

Another pronounced finding obtained in 2 of
the 7 cases, that is, a muscle bundle stretching out
from the conal septum to sandwich the conduc-
tion system in the summit of the interventricular
septum and thereby cause it to undergo block
due to fibrosis, is helpful in illustrating the
genesis of the atrioventricular conduction defect.
Why was the myocardium in the conus region
mounted on the summit portion of the septum,
not to the right of the conduction system as it
normally rise? The reason for this is unknown.
Assuming, however, that the mounting position
represents a congenital error of slight degree, one
is reminded of the possibility that the small size
of the sinus node as in Case 1 be accounted for
by its congenital defect to transfer a part of the
node to the left side in a sense, for an expres-
sion of unusually symmetrical cardiac structure.
If so, the aberrant courses of the sinus node
artery might also be explained in these terms. At
any rate, both the abnormal extension of myo-
cardial fibers from the conus and the aberrancy
of the sinus node artery are too trifling malfor-
mations to constitute any significant gross find-

ings. These anatomic errors, however, deserve utmost attention and close study if they really take part in the trait that favors the sudden death of the patient.

**Conclusion**

Our histopathological study of the conduction system in 7 cases of sudden death from Pokkuri disease or allied disease states led to the following conclusions:

1) There was a significant loss of conduction cells due to fibrosis in the sinus node or at its junctions with atrial muscle in 6 of the 7 cases.
2) The sinus node artery was found abnormally coursing or distributed in 6 cases, with its main branch not passing through but by-passing the sinus node in 3 cases.
3) There was a pathologic change in the atrioventricular conduction system in 4 cases, in 2 of which an abnormal muscle bundle from the conus was mounted on the summit of the interventricular septum to sandwich an area ranging from the distal portion of the bundle of His to the root of the bundle branches, with the consequent block due to mechanical strain. Incomplete interruption imputable to an overgrowth of adipose tissue was noted in the remaining 2 cases.
4) In 4 cases there were lesions concurring in the sinus node and the atrioventricular conduction system.
5) Premortal ECG showed left axis deviation combined with right bundle branch block in 1 case.

From the findings listed above it may be concluded that abnormalities in the conduction system are involved in the genesis of a syndrome called Pokkuri disease in at least a majority of cases. It is likely that trifling congenital anomalies such as aberrant courses of the sinus node artery or slightly abnormal location of the muscle bundle of the conus set the stage for the selective involvement of the conduction system which is peculiar to the illness.

**Acknowledgement**

The author wishes to express his heartfelt thanks to Prof. K. Tashiro of the 2nd Dep. of Pathology and Ass. Prof. R. Okada of the Dep. of Internal Medicine, Cardiology, Juntendo University, School of Medicine for their assiduous guidance in this study; To Prof. H. Nitani of the 3rd Dep. of Internal Medicine and all the staff of the 2nd Dep. of Pathology for their kind suggestions; To Prof. M. Okuda of the Dep. of Pathology, Kitaso University, School of Medicine and Lecturer H. Kobayashi of Dep. of Legal Medicine for their courtesy of providing valuable cases; and to Mrs. Y. Odagiri, Miss. Y.

Komuro and Mr. F. Shiraishi for their assistance in making up the preparations.

**References**

3. OKUDAIRA, M., et al.: Epidemic and pathological study of the acute cardiac death. This report was supported by the ministry of Education, 1972. (in Japanese)
