Acute Obstruction by Pannus in Patients With Aortic Medtronic-Hall Valves: 30 years of Experience

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Background. Acute dysfunction of mechanical aortic valve prostheses is a life-threatening adverse event. Pannus overgrowth, which is fibroelastic hyperplasia originating from the periannular area, is one cause of dysfunction. The aim of this study was to determine the annual incidence of readmittance resulting from acute obstruction caused by pannus during 30 years of observation in patients with Medtronic-Hall aortic valve prostheses and to analyze the risk factors associated with pannus development.

Methods. From 1982 to 2004, 1,187 patients in our department underwent aortic valve replacement with Medtronic-Hall mechanical monoleaflet valve prostheses. As of December 31, 2012, 27 of these patients (2.3%) had presented with acute valve dysfunction caused by pannus obstruction.

Results. The annual incidence of pannus was 0.7 per 1,000. The median time from the primary operation to prosthetic dysfunction was 11.1 years (range, 1.2 to 26.8 years). Of the 20 patients who underwent reoperation, 2 died. Seven patients died before reoperation. Women had a higher risk for the development of obstructing pannus, and patients with pannus obstruction were younger. Valve size was not an independent risk factor.

Conclusions. Women and younger patients are at higher risk for pannus development. When acute dysfunction by pannus is suspected in a mechanical aortic valve, an immediate echocardiogram and an emergency aortic valve replacement should be carried out because of the potential of a fatal outcome.

Prosthetic heart valve dysfunction may be due to endocarditis, paravalvular leakage, structural failure, valve thrombosis, or pannus. Pannus is fibroelastic hyperplasia that develops months or years after valve implantation. Acute dysfunction of mechanical aortic valve prostheses due to pannus is a rare adverse event (0.73% to 2.4%) with a high mortality rate [1, 2]. The incidence varies by type of valve prosthesis. When pannus growth is limited to the periannular area, the patient may remain asymptomatic. With continued growth, however, pannus may interpose between the prosthetic valve ring and disc. Hence, it may inhibit opening or closure of the valve disc, thereby leading to acute aortic obstruction or regurgitation. Valve dysfunction may be intermittent in the early stages, becoming permanent as growth of the fibrous tissue increases. Although several case reports and small series of patients with obstructed mechanical valves have been reported [2–5], the causes and predisposing factors of pannus are still not well defined.

The aim of this study was to analyze the incidence, treatment, and results of acute prosthetic valve obstruction due to pannus overgrowth in a large series of patients with a Medtronic-Hall tilting disc aortic prosthesis (Medtronic, Minneapolis, MN). This was a retrospective study of patients seen in our hospital during 30 years. Special attention was given to analyzing the predisposing factors of pannus development.

Material and Methods

From 1982 to 2004, 1,187 patients underwent aortic valve replacement with a Medtronic-Hall monoleaflet valve prosthesis, which was the preferred heart valve prosthesis in our department at that time. All patients were registered in our database. Upon readmission, signs and symptoms, diagnostic procedures, perioperative findings, and in-hospital adverse events were registered. Retrospective patient-information was taken from medical records. Pannus overgrowth was ascertained either at reoperation or at autopsy. The endpoints were reoperation and death.

Statistics

To compare means of continuous variables, t tests were used. Relationships between sex, valve size, and pannus
were assessed by Pearson’s χ² test and multivariate regression analysis. Analysis of variance was used to compare multiple means. Increased risk was quantified by using the odds ratio, and p < 0.05 was considered statistically significant for all tests. The analyses were performed with STATA for Mac (StataCorp 2011. Stata Statistical Software: Release 12. College Station, TX: StataCorp LP).

Results
As of December 31, 2012, 27 (2.3%) of the 1,187 patients who had undergone operation had been readmitted as a result of acute obstruction caused by pannus, resulting in an annual incidence of 0.7 per 1,000 (Fig 1). One patient underwent two reoperations but was counted as a single patient in this dataset.

Of the 27 patients in the pannus subgroup, the indications for the primary operation were aortic stenosis (14 patients), aortic regurgitation (4 patients), combined stenosis and regurgitation (8 patients), and dissection (1 patient). The distribution of comorbidity was as follows: hypertension (9 patients), diabetes mellitus (3 patients), systemic inflammatory disease (2 patients: systemic lupus erythematosus and psoriatic arthritis), and Marfan syndrome (1 patient). Five patients were active smokers at the time of the primary operation. Heavy calcification of cusps and annulus was found in 13 patients during the primary operation. Seventeen patients had a native bicuspid aortic valve.

The median valve size was 23 mm (diameter range, 20 to 29 mm). The distribution of valve sizes related to sex and number of valve implants is shown in Figure 2. Prosthetic valve implantation was carried out by either a single-stitch or a U-suture technique with the use of 2-0 Ticron sutures (Tyco Healthcare, Mansfield, MA) or 2-0 Ethibond sutures (Ethicon, Somerville, NJ). Owing to the inconsistent description of suture technique in the operative reports, no accurate distribution could be summarized. The single-stitch technique resulted in a principally intraannular position, whereas U-sutures resulted in a supraannular position. Pledgets were used in 9 patients, not used in 16 patients, and not reported in 2 patients. Generally, all implanted Medtronic-Hall valves were oriented with the major orifice facing the larger curvature of the ascending aorta. This orientation ensured optimal hemodynamic conditions to both coronary arteries, as later described by Kleine and colleagues [6]. In the patients with acute obstruction due to pannus, all valves except one were oriented in this fashion. This patient’s valve was oriented with the major orifice slightly more toward the minor curvature of the ascending aorta.

Additional procedures were performed in 9 patients: implantation of a composite aortic tubular graft (3 patients), coronary bypass grafting (1 patient), septal myectomy (1 patient), wrapping of the ascending aorta (1 patient), mitral valve replacement (1 patient), enlargement of the aortic root (1 patient), and combined coronary bypass grafting and wrapping of the ascending aorta (1 patient). The mean cardiopulmonary bypass time was 102 ± 26.5 minutes.

The median time from primary operation to valve dysfunction was 11.1 years (range, 1.2 to 26.8 years). Of the 27 patients with valve obstruction by pannus, 9 were men and 18 were women. Relative to the total number of men (775) and women (412), the group incidences were 1.2% and 4.4%, respectively. Thus, the odds ratio for the development of obstructing pannus for women was 3.89 compared with men (p = 0.001). Analysis of variance of age by valve size in the pannus cohort failed to reveal any reliable differences. Multivariate analysis of pannus, sex, and valve size showed that sex was an independent risk factor (p < 0.001; Table 1), whereas valve size was not (p = 0.052). Post hoc grouping of valves into small (≤23 mm) and large (>25 mm) sizes supported the latter finding. Patients readmitted with pannus were younger (43.5 ± 17.5 years) at the primary operation than were the 1,160 patients without pannus (58.8 ± 14.1 years, p = 0.001). Nineteen patients presented with chest pain, 16 with dyspnea, and 14 with partial or total loss of valve click. Of the latter, 6 patients had noticed the loss of valve click themselves. All patients received anticoagulant therapy with warfarin. The international normalized ratio (INR) at readmission was >2.5 in 13 patients, <2.5 in 7 patients, and unknown in 7 patients. Upon readmission, several diagnostic tools were used: transthoracic echocardiography (20 patients), cinefluoroscopy (14 patients), transesophageal echocardiography (5 patients), and angiography (4 patients). Echocardiography revealed aortic regurgitation, delayed or absent leaflet motion (Fig 3). Cinefluoroscopy showed reduced, intermittent, or absent leaflet motion (Fig 4). The usual finding at reoperation was an obstructed leaflet in a semiopen position caused by the interposition of pannus in the minor orifice, as seen in Figure 5A. All

![Fig 1. Incidence of pannus obstruction from time of primary operation. Kaplan-Meier plot of freedom from valve obstruction caused by pannus after implantation of a Medtronic-Hall aortic valve.](image-url)
patients had pannus affecting the minor orifice, whereas
the major orifice was affected in 17 patients (63%); of
these, were 10 circumferential (Fig 5B). The pannus
originated from the ventricular side in all patients.
Seven patients died before the operation; 4 during
transfer to the hospital and another 3 in the hospital
during preoperative diagnostic procedures.
Of the 20 patients who underwent reoperation, 2 pa-
tients died in the hospital. Both patients experienced a
cardiac arrest and were resuscitated preoperatively.
Although reoperations were completed successfully in
both cases, both died of heart failure in the immediate
postoperative period.
At reoperation, 6 patients received a bileaflet mechani-
cal valve, 7 a stented biological prosthesis, 3 a porcine
aortic root (Medtronic Freestyle), and 3 a new Medtronic-
Hall valve prosthesis. One patient underwent complete
debridement of pannus overgrowth and kept the previ-
ously implanted prosthesis. Of the 3 patients who
received a new Medtronic-Hall valve prosthesis, a 47-
year-old woman was readmitted 8 years later with a
second valve obstruction due to pannus. She underwent
successful reoperation for the second time, receiving a
Medtronic Freestyle aortic root.
No pacemakers were implanted after the primary valve
implantation, but after reoperation, 8 patients required a
permanent pacemaker. Seven of these were implanted
shortly after the redo operation, and 1 patient underwent
implantation 7 years later.
All 18 surviving patients had an uneventful recovery
after the operation and, as of December 31, 2012, were
reported to be alive and in good health. The follow-up
times of this cohort ranged from 2 months to more than
14 years (median, 3.7 years).

**Comment**

This 30-year follow-up of a large population of patients
who experienced valve dysfunction caused by pannus
after implantation of a Medtronic-Hall aortic valve pro-
thesis revealed several interesting issues. The most
important observation was that women had a higher risk
for pannus overgrowth than did men. Svennevig and
colleagues [7] reported that female sex was a signifi-
cant risk factor for death after aortic valve replacement, but
possible reasons were not addressed. Some authors
speculate that the higher rate of death in female patients
after aortic valve replacement may be due to implantation
of smaller prosthetic valves, resulting in higher blood-
stream velocity and increased turbulence [2, 4]. However,
in our series, pannus obstruction occurred with all
implanted valve sizes except 31-mm valves (Fig 2). Valve
size was not an independent risk factor for pannus
obstruction in our sample.

Patients experiencing pannus with acute valve
dysfunction were younger at the time of the primary
valve implantation than were the rest of the Medtronic-
Hall aortic valve cohort. Teshima and colleagues [1]
 hypothesized that a chronic periannular inflammatory
response to a foreign body triggers pannus development.
Younger patients are thought to produce stronger in-
flammatory reactions, stimulating a disproportionate
overgrowth of pannus. They are usually more physically

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**Table 1. Multivariate Analysis**

<table>
<thead>
<tr>
<th>Pannus</th>
<th>Coefficient</th>
<th>SE</th>
<th>t</th>
<th>P &gt; t</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>–0.046667</td>
<td>0.011739</td>
<td>–3.98</td>
<td>0.000</td>
<td>–0.069698 –0.023637</td>
</tr>
<tr>
<td>Valve size</td>
<td>0.004172</td>
<td>0.002141</td>
<td>1.95</td>
<td>0.052</td>
<td>–0.000029 0.008372</td>
</tr>
</tbody>
</table>

CI = confidence interval; SE = standard error.
Male = 9 female = 18.

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**Fig 2.** Distribution of valve sizes. Bars show the
distribution of Medtronic-Hall aortic valve prostheses with
pannus obstruction, stratified by size and sex. Diamonds
represent the total number of implanted Medtronic-Hall aortic valves by size.
active as well, which may cause more mechanical stress to the valvular region.

The 2.3% incidence of acute and severe valve dysfunction due to pannus overgrowth in our study sample may seem high, but it is comparable with those in two other previous studies, one on St. Jude aortic valve prostheses and the other comprising a mixed group of aortic, mitral, and tricuspid prosthetic valve prostheses [1, 8]. By contrast, two large follow-up studies of the Medtronic-Hall valve in the aortic position reported no incidence (0/736 patients) or an extremely low incidence (1/816 patients) of pannus-related valve dysfunction [7, 9]. Yet, both latter publications focused on all-cause mortality after valve implantation and its predictors in cohorts comparable with those of the present study. The low incidence of pannus reported in these studies may reflect the lack of recognition of pannus adverse events during follow-up. The high incidence of pannus observed in this study may have been due to a high degree of recognition, confirmation by either operation or autopsy, and the regional affiliation of patients to the hospital.

No relationship could be established between valve implantation technique and the development of pannus overgrowth. All the different suture techniques and suture materials used throughout the 30-year study period are represented in our sample. Pledgets may have been a triggering agent for pannus formation in some cases; however, it was not a common factor, given that pledges were used in only 9 (33%) of the patients with obstructing pannus.

The time range between the primary operation and valve prosthesis dysfunction was wide but similar to that of Vitale and colleagues [10]. They reported pannus obstruction ranging from some days to 12 years postoperatively in their study on pathologic findings of obstructed mitral prosthetic valves. Kondruweit and colleagues [4] reported a case of valve obstruction caused by pannus 6 months after operation. Thus, it is clinically important to consider pannus as a cause of acute dysfunction, irrespective of time since the valve prosthesis implantation (Fig 1).

In our series, inadequate INR level at admission (<2.5) could not be identified as a risk factor for fibrous tissue overgrowth. Low INR is a major risk factor for valve thrombosis, and pannus is often seen with a superimposed thrombus, thereby enhancing the obstructing effect on the monodisc prosthesis [11].

Most patients presented with acute chest pain, dyspnea, and loss of valve click. The latter is a pathognomonic sign of valve obstruction observed in more than half of the cases, either at auscultation or by a family member.

In some cases the obstruction can be intermittent because of limited interference by pannus on leaflet movements. This may explain why several patients experienced brief similar spells before admission to the hospital. This may also explain how the severe clinical condition of 1 of our patients improved considerably after he received a precordial thump. In this case the blow forced the leaflet open, allowing resumption of some cardiac output. An intermittent impairment of valve leaflet excursion may also induce false negative results of diagnostic procedures.

Three patients with pannus died while undergoing a diagnostic procedure. However, diagnostic procedures
are necessary to confirm the suspicion of prosthetic valve obstruction due to fibrous tissue overgrowth. Several different diagnostic investigations were applied in our series, inasmuch as our experience spans more than three decades and reflects the shift in diagnostic procedures during this period. In the past two decades, echocardiography has been considered as the primary diagnostic tool for prosthetic valve dysfunction. Echocardiography may both reveal reliable signs of prosthesis failure by pannus and provide valuable information in cases of circulatory collapse from other causes. An echocardiogram should be carried out as quickly as possible so the patient eventually can be transferred to an operating room once the diagnosis of prosthetic valve obstruction due to pannus is established.

For restriction of leaflet movement to occur, the pannus has to interpose between the leaflet and the ring. The design of a tilting disc valve is more prone to fibrous tissue obstruction than a bileaflet valve. The reason is probably a combination of the low prosthetic ring profile and a greater leaflet protrusion below the ring on the ventricular side in the tilting disc design [2]. Furthermore, in bileaflet prosthetic valves, one leaflet may still be functional, even though the other leaflet is blocked by fibrous tissue. Because of these factors and because the Medtronic-Hall valve has not been in production since 2007, we no longer use this valve in our surgical practice.

Suboptimal blood flow patterns and shear stress in the left ventricular outflow tract, high transvalvular pressure gradients, and incorrect valve orientation are all factors that may contribute to fibrous tissue overgrowth [6]. In our series, all patients had pannus affection of the minor orifice (Fig 5B). Speculations about whether the minor orifice creates predisposing blood flow patterns or whether the septum is more prone to pannus formation may be confounded by patient selection. If septal hypertrophy had been a key factor for pannus formation, a higher incidence of readmission resulting from pannus obstruction would be expected.

The limitations of our study are primarily those related to its retrospective design. Our hospital has the only cardiothoracic surgical unit in western Norway. Patients in this area requiring urgent or emergent cardiothoracic surgical treatment are taken to our hospital. However, there is still a small chance that patients with acute prosthetic valve obstruction may have been taken to other hospitals or may have died suddenly. Thus, the 2.3% incidence of acute and severe valve dysfunction caused by pannus may be an underestimation when the country is considered as a whole.

In conclusion, this study showed that women and younger patients with a Medtronic-Hall aortic valve prosthesis are at higher risk for the development of acute valve obstruction caused by fibrous tissue overgrowth. Once sudden prosthetic valve obstruction is suspected and confirmed by immediate echocardiography, surgical treatment should be carried out without delay because of its emergency nature and potential of fatal outcome.

References

INVITED COMMENTARY

It would be easy to dismiss the study by Ellensen and colleagues [1] as one of only historical interest, given that the Medtronic-Hall valve is no longer in use. The valve itself is an elegant design but is not relevant in today’s “bileaflet world.” This comprehensive data set, however, gives us insight into a complication of mechanical valves common to all in character, albeit uncommon in occurrence: pannus formation.

The incidence of pannus causing acute dysfunction in this study was 0.7/1,000 patient-years. This may be something of an underestimate, given that some pannus might occur causing stenosis without overt valve failure, even given a single-disc design. It is also conceivable that differences in the composition of the sewing rings could impact its development. Still, these data give us a reasonable estimate of the risk of pannus formation in the setting of a mechanical valve, a complication I always mention to a patient choosing a prosthesis but one for which I have not had handy number.

The findings in this study also alert us to the serious nature of this complication, with one-quarter of individuals dying before surgical intervention could be accomplished and 2 dying during the reoperative procedure, for an overall mortality rate of 33%. It is unfortunate that the only risk factor identified is an unmodifiable one: female gender.

Unfortunately, the details of suture technique, including use or nonuse of pledgets, were incomplete as was information on supraannular vs intraannular implantation, so the authors cannot give us technical advice for prevention. This leaves us with only the admonition to proceed without delay to definitive diagnostic and therapeutic measures when the diagnosis is suspected. Surely, that is of value to us all.

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