Current Status of Emergency Care for ST-Elevation Myocardial Infarction in an Urban Setting in Japan

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Background The door-to-balloon time (DTB) is an important predictor of the outcome for patients with ST-elevation myocardial infarction (STEMI). In Japan, percutaneous coronary intervention (PCI) can be performed at many hospitals, and the predominant strategy for reperfusion therapy is primary PCI. However, it remains unclear how rapidly reperfusion is achieved at these hospitals.

Methods and Results The study group comprised 369 patients with STEMI who presented within 12h of symptom onset to a tertiary emergency center (TEC) or at 11 community hospitals (CHs) in 2006 and underwent emergency coronary angiography. Median DTB was shorter in the TEC (63 vs 104 min, P<0.001), and the rate of DTB within 90 min was higher in the TEC (96% vs 39%, P<0.001). Lateral myocardial infarction, presentation during off-hours, and non-cardiologist as the first-contact physician were significantly associated with a prolonged DTB in CHs. There was a trend toward lower 30-day mortality from all causes in the TEC (2.0% vs 4.8%, P=0.08). Multiple logistic regression analysis demonstrated that prolonged DTB (>90 min) was an independent predictor of 30-day mortality (odds ratio 12.6; 95% confidence interval 1.85–86.2, P=0.01).

Conclusions Establishment of emergency cardiac care systems with the goal of DTB within 90 min is required in PCI-capable hospitals to improve clinical outcomes.

Key Words: Acute myocardial infarction (AMI); Door-to-balloon time; Mortality; Reperfusion

The time from hospital admission to reperfusion is an important predictor of the outcome for patients with ST-elevation myocardial infarction (STEMI)[1-3] Guidelines for the management of STEMI issued by the American College of Cardiology/American Heart Association and the European Society of Cardiology recommend primary percutaneous coronary intervention (PCI) for reperfusion therapy when it can be performed in a timely manner (ie, door-to-balloon time (DTB) or first medical contact-to-balloon time within 90 min) by experienced operators at high-volume centers[4,5] However, emergency primary PCI is not always feasible, and treatment is frequently delayed. In Japan, PCI can be performed at many hospitals, and the predominant strategy for reperfusion therapy is primary PCI[6-9] but how rapidly reperfusion is achieved in Japanese hospitals that routinely perform PCI remains unclear. Drugs, devices, and techniques for primary PCI have been actively debated, whereas shortening the time to reperfusion has only recently received attention. This study evaluated DTB and analyzed its components in patients with STEMI who were admitted to emergency hospitals in an urban setting in Japan and examined differences in DTB according to the type of hospital.

Methods

Study Population

We retrospectively studied 369 patients (283 men, 86 women; mean age, 65 years) with STEMI who were admitted to 12 emergency hospitals in an urban setting in Japan and underwent emergency coronary angiography within 12h after symptom onset. Patients with out-of-hospital cardiac arrest were excluded. All subjects had to have typical chest pain lasting for 20 min or more and ST-segment elevation in at least 2 adjacent leads (>0.1 mV in leads II, III, aVF, aVL, V4–6 and >0.2 mV in leads V1–3) on the admission electrocardiogram (ECG). The diagnosis of acute myocardial infarction (AMI) was confirmed by an increase in the creatine kinase level to more than twice the upper limit of normal. Another 20 patients with STEMI within 12h after symptom onset were hospitalized during the study period, but did not undergo urgent cardiac catheterization because of advanced age or comorbidity. No patient

Table 1   Capabilities of the 2 Types of Hospitals

	TEC (n=1)	CHs (n=11)
No. beds	720	239–601*
No. cardiologists	14	4–8*
Annual no. total PCI ≥200	+	3/11
Interventional capability for 24 h/7 days	+	10/11
Cardiologists on duty for 24 h/7 days	+	3/11
Cardiologists always initially evaluate patients with chest discomfort in the emergency department	+	1/11
On-site cardiac surgical back-up	+	3/11
Pre-hospital 12-lead ECG transmission system	+	–

*Range.

TEC, tertiary emergency center; CHs, community hospitals; PCI, percutaneous coronary intervention; ECG, electrocardiogram.

Table 2   Baseline Characteristics of the Patients

	TEC (n=98)	CHs (n=271)	P value
Age (years)	62.3±10.8	66.6±11.7	0.002
Gender, M	80 (82%)	203 (75%)	0.18
Medical history			
Hypertension	57 (58%)	148 (55%)	0.54
Dyslipidemia	44 (45%)	116 (43%)	0.66
Diabetes mellitus	36 (37%)	102 (38%)	0.93
Previous myocardial infarction	8 (8%)	20 (7%)	0.81
Previous bypass surgery	2 (2%)	4 (1%)	0.51
Infarct location			
Anterior	38 (39%)	130 (48%)	0.12
Inferior	48 (49%)	105 (39%)	0.08
Lateral	7 (7%)	21 (8%)	0.85
Time and mode of presentation			
Presentation during regular hours	49 (50%)	134 (49%)	0.93
Presentation by self-transport	4 (4%)	69 (25%)	<0.001
Inter-hospital transfer	30 (31%)	57 (21%)	0.06
Cardiologist as 'first-contact' physician	94 (96%)	117 (45%)	<0.001
Killip class ≥2	10 (10%)	34 (13%)	0.54
Fibrinolytic therapy with facilitated PCI	42 (43%)	93 (34%)	0.13

Abbreviations see in Table 1.

received thrombolytic therapy without coronary angiography. All clinical data were collected from medical records by a single researcher. The 12 participating institutions consisted of 1 tertiary emergency center (TEC) and 11 community hospitals (CHs), all of which could perform PCI. The study period was from January through December 2006.

Data Analysis and Definition

We compared the institutional and patients' baseline characteristics between the TEC and CHs. Time factors such as DTB and its components were also compared. We then analyzed variables associated with treatment delays and clinical outcomes.

Door time was defined as the arrival time at the emergency department where emergency cardiac catheterization was performed (not the arrival time at referral hospitals for transferred patients). Balloon time was defined as the time of first balloon inflation, or the time of stent implantation if the patient underwent primary stenting. PCI was considered successful if a Thrombolysis In Myocardial Infarction (TIMI) flow grade of 2–3 was obtained in the infarct-related artery in the presence of <50% residual stenosis with balloon angioplasty or <20% residual stenosis with stent implantation. If initial angiography showed TIMI grade 3 flow with >75% stenosis, additional PCI was left to the discretion of the attending physician.

Presentation time was divided into "regular hours"

(defined as weekdays from 08.30–19.59 h) and "off-hours" (weekdays from 20.00–08.29 h and weekends).

Statistical Analysis

Statistical analysis was performed with SPSS 11.0 for Windows (SPSS, Inc, Chicago, IL, USA). The Kolmogorov-Sminov test was used to analyze the normality of the distribution of the study variables. Values are expressed as mean ± SD or median with interquartile ranges. Univariate comparisons of continuous variables between groups were done with unpaired t-tests for normally distributed variables and Mann-Whitney tests for skewed variables. Categorical variables were compared with chi-square tests or Fisher's exact test. Multivariable logistic-regression analysis was performed with the variables that were significantly related to outcome variables in the univariate analyses to determine predictors of DTB within 90 min and of 30-day mortality. Differences were considered significant at $P<0.05$.

Results

Hospital Characteristics

Table 1 shows the characteristics of the hospitals. The TEC was a high-volume center with many strategies to reduce the DTB. An attending cardiologist is always available to examine patients who present with chest discomfort at the emergency department, as compared with only 1 of the 11

Table 3 Angiographic Findings and Interventional Procedure Rates

	TEC (n=98)	CHs (n=271)	P value
Initial TIMI flow grade 0	46 (47%)	124 (46%)	0.84
POBA and/or stent implantation	80 (82%)	231 (85%)	0.40
Thrombectomy	13 (13%)	83 (31%)	0.001
Distal protection	9 (9%)	3 (1%)	<0.001
Pre intravascular ultrasound	74 (76%)	47 (17%)	<0.001
Temporary pacing	1 (1%)	22 (8%)	0.001
Final TIMI flow grade 3	86 (88%)	242 (89%)	0.68
PCI success	77 (96%)	226 (98%)	0.34

TIMI, Thrombolysis In Myocardial Infarction; POBA, plain old balloon angioplasty. Other abbreviations see in Table 1.

Table 4 Time Factors Related to Reperfusion

	TEC	CHs	P value
Symptom onset-admission (min)	83 (51, 142)	100 (56, 180)	0.08
Admission-ECG (min)	4 (3, 5)	4 (2, 7)	0.67
ECG-catheterization laboratory (min)	20 (16, 25)	45 (35, 69)	<0.001
Catheterization laboratory-CAG (min)	13 (11, 16)	18 (15, 23)	<0.001
CAG-balloon (min)	24 (20, 31)	26 (19, 38)	0.28
Door-balloon (min)	63 (55, 70)	101 (83, 134)	<0.001
DTB within 90 min	96%	39%	<0.001

Values are median with interquartile ranges.
CAG, first coronary angiography; DTB, door-to-balloon time. Other abbreviations see in Table 1.
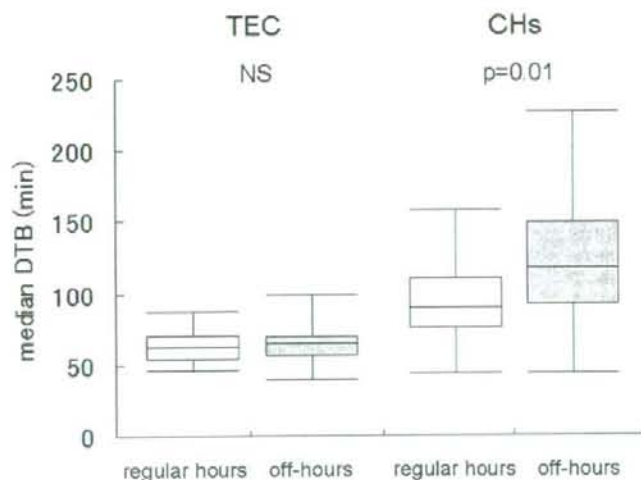

Fig 1. Median door-to-balloon time (DTB) during regular hours and off-hours in each hospital type. TEC, tertiary emergency center; CHs, community hospitals.

CHs. The TEC has a pre-hospital 12-lead ECG transmission system from the ambulance to the emergency department, and ECG transmission was performed in approximately 50% of the TEC patients.

Patients' Characteristics

Within the overall study group, 98 (27%) patients were admitted to the TEC and 271 (73%) to CHs. There was no difference in sex, infarct location, or the rate of Killip class ≥2 between the 2 types of institution. The patients admitted to TEC were younger than those admitted to CHs. Fibrinolytic therapy with low-dose tissue plasminogen activator with facilitated PCI was performed in 42 patients (43%) in the TEC and in 93 (34%) patients in the CHs. Overall, 15 patients who received fibrinolytic agents did not undergo PCI

because of successful reperfusion as confirmed by coronary angiography, without balloon angioplasty. These patients were excluded from the analysis regarding the time from CAG to first balloon inflation. First-contact physicians were more frequently cardiologists in the TEC. The proportion of patients transferred from other hospitals was higher in the TEC, whereas the rate of self-transport to the hospital was significantly lower (**Table 2**).

Angiographic Findings and Interventional Procedure Rate

The frequency of PCI-related procedures such as thrombectomy, use of distal protection devices, and pre-intravascular ultrasound differed between the 2 types of institution. Balloon angioplasty (POBA), stent implantation, or both were performed in 82% of the patients in the TEC and in

Table 5   Variables Associated With Prolonged DTB (>90 min) in Patients Admitted to CHs

	Univariate analysis	P value	Multivariate analysis	95%CI	P value
Annual PCI procedures <200 in admitting hospital*	1.09	0.76	–	–	–
Cardiogenic shock	0.36	0.045	–	–	0.16
Lateral wall infarction	3.45	0.043	3.85	1.01–14.8	0.049
Presentation during off-hours	3.39	<0.001	2.94	1.63–5.31	<0.001
Presentation by self-transport	2.3	0.014	–	–	0.10
Inter-hospital transfer	0.41	0.004	–	–	0.37
Non-cardiologist as 'first-contact physician'	4.13	<0.001	3.63	2.02–6.52	<0.001

ORs of prolonged DBT are shown. Variables reaching P<0.05 on univariate analysis were entered into the multivariate analysis.
*Although annual PCI volume is included, it was not associated with prolonged DBT and was not entered into the multivariate analysis.
CI, confidence interval; OR, odds ratio. Other abbreviations see in Tables 1,4.

Table 6   Multivariate Predictors of All-Cause 30-Day Mortality

	OR	95%CI	P value
Age >75 years	11.4	2.05–63.3	0.005
DTB >90 min	12.6	1.85–86.2	0.01
Killip class ≥2	34.3	5.56–211.2	<0.001
Final TIMI flow grade ≤2	25.5	2.75–236.7	0.004
Anterior myocardial infarction	11.8	1.34–103.3	0.03

Variables reaching P<0.05 on univariate analysis were entered into the multivariate analysis.
Abbreviations see in Tables 3,4.

85% of those in CHs. PCI was successful in 95% of the patients treated in the TEC and in 98% of those treated in CHs. The proportion of patients with a final TIMI flow grade of 3 did not differ between the TEC and CHs (Table 3).

Time Factors Related to Reperfusion and Clinical Outcome

The time from symptom onset to admission was slightly but not significantly longer in the CHs. The time from admission to ECG recording and the time from first coronary angiography to first balloon inflation were similar in the 2 types of hospital. However, the time from ECG recording to the cardiac catheterization laboratory was significantly longer in the CHs, resulting in a longer DTB. The TEC had a median DTB of 63 min and achieved a guideline-recommended DTB within 90 min in 96% of patients, whereas the CHs had a median DTB of 101 min and only 39% of patients achieved a DTB within 90 min (Table 4). Presentation during off-hours significantly prolonged the DTB for 27 min as compared with presentation in regular hours in the CHs, whereas the time of presentation did not influence the DTB in the TEC (Fig 1). Moreover, treatment was markedly delayed (DTB >150 min) in 18% of the patients treated at CHs, and this increased to 30% when a non-cardiologist was the first-contact physician. There was a trend toward lower 30-day mortality from all causes in the TEC in the overall study group (2.0% vs 4.8%, P=0.08).

Variables Influencing DTB in CHs

Because a guideline-recommended DTB was achieved in most of the patients treated in the TEC, the variables that influence the DTB were analyzed among the patients who were admitted to a CH. Hospitals that performed more than 200 PCI per year did not have a shorter DTB than hospitals that performed less procedures. After multivariable adjustment, lateral MI, presentation during off-hours, and non-cardiologist as first-contact physician were significantly

associated with a prolonged DTB (Table 5). Inter-hospital transportation occurred in 21% of patients admitted to a CH, but was not a significant factor for DTB >90 min on multivariate analysis. After excluding referred patients and analyzing data only from patients with direct transportation, the results for time factors were similar to those obtained for the study group as a whole.

Analysis of Predictors of 30-Day Mortality

Table 6 shows the predictors of 30-day mortality from all causes in patients who underwent emergency PCI. Multiple logistic regression analysis showed that age >75 years, anterior MI, Killip class ≥2, final TIMI flow grade ≤2, and DTB >90 min were independent predictors of mortality within 30 days.

Discussion

Our study showed that CHs achieved the guideline-recommended DTB in less than 40% of patients with STEMI, and that prolonged DTB was an independent predictor of 30-day mortality. Delayed treatment was associated with patient presentation during off-hours and non-cardiologists as the first-contact physician. In contrast, the TEC, which specialized in cardiac emergency care, performed rapid reperfusion therapy in most patients.

Prompt PCI significantly reduces mortality and morbidity in patients with STEMI, and prolonged DTB has been associated with poor outcomes![1-5,10] However, most previous studies were performed in Western countries at medical centers with experienced PCI providers. We investigated whether a similar situation exists in Japanese hospitals. In contrast to Western countries, many hospitals in Japan can perform PCI and consequently, 75–94% of patients with STEMI undergo primary PCI for reperfusion therapy[6-8] including those treated at low-volume centers![11,12] Our findings showed that PCI volume at the CHs was unrelated to

either DTB or 30-day mortality in contrast to results obtained by Western studies, where a prolonged DTB was associated with higher 30-day mortality. This outcome suggests that the establishment of emergency cardiac care systems is a more important factor in the reduction of DTB than the treatment of patients with STEMI at high-volume centers, consistent with the recommendations of "Development of System of Care for ST-Elevation Myocardial Infarction," issued by the American Heart Association[13] A recent study has shown that hospital policies that emphasize having a well-equipped catheterization laboratory staffed by attending cardiologists and other dedicated care providers contributes to a reduced DTB[14] In another study, the establishment of protocols requiring that the cardiac catheterization laboratory is activated by emergency department physicians and that patients with cardiac problems are immediately transferred and treated at catheterization laboratory significantly reduced DTB by 38 min overall[15] contributing to a decrease in mean infarct size.

Our study found that non-cardiologists as first-contact physician and off-hour presentation were associated with prolonged DTB in Japan. In the CHs, more than half of the patients with STEMI were initially treated by a non-cardiologist, who quickly obtained a 12-lead ECG for patients who had symptoms suggesting STEMI, but the time from ECG to the catheterization laboratory remained prolonged. The time from first coronary angiography to first balloon inflation, the PCI success rate, and the proportion of patients with a final TIMI flow grade of 3 did not differ between the CHs and TEC, suggesting the cardiologists were unaware of treatment delays that occurred before they were consulted. Ideally, all patients with symptoms suggesting STEMI should be examined by a cardiologist immediately after admission; however, most CHs do not have a 24-h on-site attending cardiologist 7 days per week because of limited human and financial resources. Non-cardiologists should therefore be aware of the clinical significance of the DTB and immediately transfer patients suspected to have STEMI to the cardiac catheterization laboratory.

In Vienna, Austria, the establishment of a cooperative network and implementation of the guidelines for the treatment of STEMI led to earlier reperfusion therapy and significantly improved clinical outcomes[16] Pre-hospital ECG transmission enables on-call cardiologists to be notified before the patient arrives in the emergency department and reduces PCI-related delays, with earlier activation of the catheterization laboratory[17–19] We believe that pre-hospital ECG transmission and analysis contributed substantially to the higher rate of a DTB within 90 min at the TEC in our study.

In conclusion, our results suggest that the design and implementation of appropriate guidelines and the improvement of hospital performance through the organization and establishment of emergency cardiac care systems will consistently ensure rapid reperfusion in patients with STEMI. Optimal policies tailored to meet the needs of specific communities are likely to reduce the DTB and lead to improved outcomes.

Study Limitations

This study included a small number of patients and was performed in a single region of Japan. Overall, 37% of patients underwent facilitated PCI with a half-dose of tissue plasminogen activator; negative results after facilitated PCI have been reported[20,21] but several studies, including the

Comparison of Angioplasty and Prehospital Thrombolysis In acute Myocardial infarction (CAPTIM) trial[22] the Vienna registry[16] and the National Registry of Myocardial Infarction (NRMI)[18] have demonstrated the effectiveness of fibrinolytic therapy early after the onset of MI. In addition, the former 2 trials also confirmed the efficacy of immediate PCI after fibrinolytic therapy[16,22,23] We therefore administered a half-dose of fibrinolytic therapy followed by PCI in younger patients who presented early after onset.

Although the DTB at the TEC was within guideline recommendations in nearly all patients with STEMI, a direct comparison with the results of previous Western studies is precluded by differences in the definition of the DTB for transferred patients. Indeed, inter-hospital transfer has been found to be a strong independent predictor of a delayed time from first hospital arrival to first balloon inflation[24] but the present study focused on hospital performance to identify in-hospital problems that need to be solved. Furthermore, we must recognize that emergency care systems in Japan might differ considerably from those in Western countries.

Conclusion

A DTB longer than 90 min was associated with a higher 30-day mortality in Japanese patients with STEMI. Guideline-recommended DTB was achieved in most of the patients in the TEC, as compared with less than 40% in CHs. Although the DTB was frequently longer in CHs, there was no correlation between PCI volume and DTB. Establishment of emergency systems for STEMI care with the goal of a DTB within 90 min is required in PCI-capable hospitals to improve clinical outcomes.

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8. 縦隔炎と感染予防

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Ⅰ. 基本的な考え方

　近年, 心臓血管外科領域においては手術手技の改良や人工材料の発達により, その手術成績は飛躍的に向上してきている. しかしながら現在においても, 術後に遭遇する感染症は患者の予後を左右するもっとも重篤な合併症の一つである. 心臓血管外科手術は本来無菌手術であるが, 体外循環や多数の血管内留置カテーテル, さまざまな人工材料の体内留置などにより, 術中・術後に体内に病原微生物が移入されやすく, また感染への抵抗性も低下して宿主と病原菌の力関係が逆転し, 術後に感染症を発症するリスクは高い. 心臓血管外科医にとって, この感染ならびに感染準備状態をいかにコントロールするかは, 手術成績を左右する重大な問題となる.

　本稿においては, 心臓血管外科周術期における感染予防対策, 術後に問題となる感染症対策および縦隔炎の診断と治療方針について述べる.

Ⅱ. 心臓血管外科手術後の感染症予防対策

　術後の感染には, 患者自身が有する常在菌による感染 (内因性感染) と, ICU や病室に存在する院内環境汚染菌による感染 (外因性感染) がある. これらの術後感染を防止するためには, すべての体内への細菌の侵入をいかに防止するかにある. その対策として, これまでに Centers for Disease Control and Prevention (CDC) をはじめとするさまざまな「感染症対策ガイドライン」[1]

が示されているが, 院内環境や感染対策状況は施設によってさまざまであり, 通常の標準的感染予防対策 (standard precaution) に加えて, 各施設, 各診療科に応じた「感染対策マニュアル」を作成し対応していくことが必要である (表1). そこで, 心臓血管外科手術後の感染症予防対策について, その特徴的対策としてわれわれの施設が行っている方法を中心に, 術前・術中・術後について述べる.

❶ 予防的抗菌薬投与

　心臓血管外科手術は無菌手術であるが, 皮膚切開を必ず伴うため皮膚に常在する表皮ブドウ球菌や黄色ブドウ球菌による内因性感染を対象とし抗菌薬を投与する. 一般的に第一世代セフェム系薬 (cefazolin) やペニシリン系薬 (ampicillin と sulbactam の合剤) などが用いられる. 定期的なメチシリン耐性黄色ブドウ球菌 (MRSA) prevalence rate 調査を行うことを原則とし, 特に MRSA 保菌例や院内環境で MRSA が多いと判断される状況のときは, 発症阻止のため vancomycin を使用する[2] (健康保険非適用). 手術部位の細菌汚染が始まるのは皮膚切開時であり, そのときに抗菌薬が血中および組織中の殺菌的濃度に達していることが必要であり, 皮膚切開の 30 分前に投与する. Cefazolin は半減期が約 2 時間であり, 組織中の抗菌薬濃度を閉創まで十分に殺菌的な水準に維持するため, 手術開始 3〜4 時間後には追加投与が必要となる. 半減期の長い vancomycin においても手術開始 6 時間後には追加投

表 1. 心臓血管外科手術後の感染症予防対策

1. 環境対策
 standard precaution の徹底
 感染対策マニュアルの作成
2. 術前対策
 術前禁煙, 術前シャワー浴
 手術直前にクリッパーによる除毛
 術前監視培養(mupirocin 塗布, povidone-iodine 希釈液によるうがい)
3. 術中対策
 maximal barrier precaution の徹底
 手術時間の短縮
 3 時間ごとの手袋の交換
4. 術後対策
 気管チューブ・血管カテーテル・尿道カテーテルの早期抜去
 早期離床, 早期経口摂取開始, 厳格な血糖コントロール
 適切な創部管理

与が必要である. 投与期間については, これまでにさまざまな臨床研究がなされてきたが, 米国胸部外科学会のガイドラインでは, 耐性菌の出現も考慮し, 心臓血管外科手術後 48 時間までの投与が推奨されている[3].

❷ 術前予防対策

術後の感染症を予防するために, 入院時にう歯の有無, 喫煙, 血糖管理状況など術前のリスクファクターについて評価する. MRSA の鼻腔内保菌が手術部位感染 (surgical site infection: SSI) のリスクファクターであることは多数報告されており[4], 鼻腔・咽頭の監視培養を行う. 監視培養で MRSA が検出された場合には, 緊急例以外は mupirocin 塗布による除菌や povidone-iodine 希釈液によるうがいを行う. 当施設では週 1 回の検査で連続 2 回の陰性を確認してから手術に臨んでいる. 原則的に, 手術前日には液体石鹸を用いシャワー浴を行う. 術前の剃毛は原則的に行わず, 必要な場合のみ手術当日, 手術室にてハサミやクリッパーを用いて行う.

❸ 術中予防対策

十分な手洗いの後でも 3 時間経過すると手指に表皮常在細菌が認められることが報告されており, 手術時間の短縮を心がけ, 約 3 時間ごとに速乾性手指消毒剤を使用し手袋の交換や, 再度手洗いをするなどの配慮が必要である. 閉胸前に縦隔, 心嚢内を生理食塩水で十分に洗浄し, 落下細菌や血腫などを十分に除去する. 術後感染症の原因菌の多くは術中・術後に体内に移入するので, 外科医のみならず麻酔医, 看護師, 臨床工学技師などの無菌操作もきわめて重要である. 手術室へ

の入室人数が増加すると浮遊粉塵が多くなり, 病原微生物が混入しやすくなるため, 手術室への入室を制限することも重要である. 血管内用具留置時, 静脈内投与薬剤の準備, および投与に際しては, 無菌法の原則を順守する. 特に中心静脈カテーテル挿入の際には, maximal barrier precaution に沿って帽子, マスクを着用し, 手洗いの後, 滅菌ガウンと滅菌手袋を着用して行う. すなわち術中においては, ① 手術室の環境対策, ② 血管確保時の無菌対策, ③ 手術操作に関する感染対策が重要である.

❹ 術後予防対策

感染起因菌の侵入部位は, 創部のみならず血管ライン刺入部, ドレーン挿入部, 気管チューブ, 尿道カテーテルなどさまざまであり, それらのラインを早期に抜去することが重要である. また栄養管理を考慮し, 早期離床, 早期経口摂取開始を行う. 一期的に閉鎖した切開創は, 72 時間以内に接合面が接着する. そのため原則的に術後 3 日間, 術中の滅菌ドレッシング剤で保護し, それ以降は開放とする. ただし創部より滲出液などがあった場合には, その症例ごとに対応する. 包交の前後では必ず手洗いを行い, 手袋を着用し包交を行う. 高血糖時には白血球の機能 (遊走, 接着, 貪食, 殺菌能) が障害されると考えられており, 周術期において感染を生じやすい状態となるため, 特に術後 48 時間以内は血糖を厳格にコントロール (血糖値を 200 mg/dl 以下) する[5].

すなわち術後は, ① 体内への挿入ライン (カテーテルやドレーン) および創部の管理, ② 術後の栄養, 血糖管理が重要である.

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┌─────────────────────────────┐
│ 不明熱，WBC 上昇，CRP 上昇 │
└─────────────────────────────┘
              ↓
┌─────────────────────────────┐
│ 診察（創部，咽頭，胸部，腹部，尿路）│
│ 胸腹部 X 線像，カテーテル刺入部観察 │
└─────────────────────────────┘
              ↓
┌─────────────────────────────┐
│ 細菌培養検査（Gram 染色）      │
└─────────────────────────────┘
   ┌────┬────┬────┬────┬────┐
   │血液│喀痰│尿 │創部│便 │
   └────┴────┴────┴────┴────┘
              ↓
┌─────────────────────────────────────────┐
│ empiric therapy による抗菌薬投与（患者背景を考慮して）│
└─────────────────────────────────────────┘
              ↓
┌─────────────────────────────┐
│ definitive therapy による抗菌薬投与 │
└─────────────────────────────┘
              ↓
        ┌──────────┐
        │ 効果判定 │
        └──────────┘
```

図 1. 術後感染症に対する抗菌薬投与方針

表 2. 縦隔炎発症のリスクファクター

宿主要因	手術要因	術後要因
高齢	手術時間延長	長期 ICU 滞在
肥満	術後出血	（長期挿管）
MRSA 保菌	両側内胸動脈使用	気管切開
糖尿病	輸血	術後肺炎
慢性閉塞性肺障害		
喫煙		
術前心不全		
腎不全		
再手術		
緊急手術		

❺ 術後感染症対策

予防的抗菌薬を終了後，発熱や炎症所見が遷延，再上昇した場合には，盲目的に広域スペクトラムの抗菌薬を用いるのではなく，感染部位，起因菌の同定に努め，感受性，感染部位に応じた抗菌薬を選択することが重要である（図1）．起因菌検索のため，病歴の間診と同時に必ず身体診察を行い，局所の圧痛，腫脹，痰，咽頭痛，歯痛，排尿痛，頭痛，下痢，関節痛など丹念に聴取しながら診察する．臨床検査では末梢血液検査，尿検査などのほかに，喀痰，尿，血液の細菌培養検査は必須である．それ以外に，局所に排膿があった場合には同部位の培養，または必要に応じて便培養を採取する．起因菌の特定がもっとも基本であるが，培養検査では菌の同定や感受性試験の結果までに時間がかかるため，Gram 染色による鏡検が抗菌薬投与の手がかりとなる．鏡検によって Gram 陽性球菌による重症感染症が疑われた場合には，初期治療から vancomycin を投与する．起因菌と感受性が判明した時点において，より抗菌力が強く，毒性が低く，抗菌スペクトラムの狭い薬剤に変更する．抗菌薬を投与する場合には，pharmacokinetics（PK）/pharmacodynamics（PD）を考慮し，投与回数，投与量を十分に検討することが重要である．心臓血管外科手術後の感染症には，①SSI と②術野外感染（remote infection）があり，その双方への留意が必要である．

Ⅲ. 術後感染性心内膜炎

心臓血管外科手術後に感染性心内膜炎を合併する危険性は 2% 以下[6]と報告されているが，一度罹患した場合には敗血症を伴い，死亡率が約 20% と重篤な合併症である．特に人工弁置換術後の心内膜炎では，予後は不良である．原因菌としては連鎖球菌，ブドウ球菌，腸球菌が多く，菌種に応じた抗菌薬の投与が重要である．原因菌が同定できない場合においても，ガイドラインに従い抗菌薬を投与する[7]．診断は，心臓超音波検査で vegetation を認め，血液培養で菌血症を証明する．内科治療に抵抗性で抗菌薬の投与でも炎症反応が改善しない場合，vegetation が増大傾向にあるときや心不全がコントロールできない場合には外科治療が必要となる．

Ⅳ. 縦隔炎

❶ リスクファクターと診断

縦隔炎は，現在においても心臓血管外科手術後の 0.5～3.3% に発症し，その死亡率も 5.4～23% と高く[8~12]，術後の SSI の中でもっとも重篤な感染症の一つである．宿主側の要因としては高齢，肥満，MRSA 保菌，糖尿病，慢性閉塞性肺障害，喫煙，腎不全，再手術，緊急手術などであり，手術要因としては手術時間，術後出血，両側内胸動脈使用，輸血であり，術後要因としては長期 ICU 滞在（長期挿管），気管切開などがあげられている（表2）．

手術後に発熱や WBC 数や CRP の上昇に加え，胸骨の痛みや発赤および動揺，創部やドレーンから膿汁が認められた場合には縦隔炎を疑う．診断

には局所の細菌培養検査のほか，胸部 CT が有用である．胸部 CT で縦隔内に air bubble や ring enhance される液体の貯留，胸骨離開や骨髄炎像が認められた場合には縦隔炎と診断する．臨床症状が乏しく CT などで診断が困難な場合には，FDG-PET によって胸骨や胸骨裏面のブドウ糖の異常消費を調べることも，診断の補助手段として有用である．起因菌は表皮ブドウ球菌と黄色ブドウ球菌が約 40〜70% と多く，その半数が MRSA と報告されている[6,8〜12]．

❷ 縦隔炎の治療

治療には，抗菌薬に加えて外科的処置が必要になる．胸骨の破壊が軽度の場合や膿瘍が限局している場合には，局所のデブリドマン，生理食塩水による洗浄および SB パック（住友ベークライト社，東京）などによる持続陰圧吸引で治療する．消毒薬は創傷治癒に働く細胞を傷害し創の治癒を遷延させるため，局所の消毒薬での洗浄や抗菌薬の塗布は行わない．炎症が強く胸骨が大きく破壊されている場合には，これまでに抗菌薬や消毒薬による洗浄の後，二期的な胸骨閉鎖や抗菌薬による閉鎖式縦隔洗浄，大網や大胸筋充填などが行われてきたが，最近では胸骨を開放しスポンジと SB パックなどを用いた陰圧閉鎖式持続吸引ドレナージ（vacuum assisted closure：VAC）が行われるようになり，治癒率をより向上させている．また VAC 療法と併用し，死腔に大網や大胸筋などを充填することや，胸骨閉鎖，有茎筋皮弁なども有効であると報告されている[13〜15]．胸骨の破壊や炎症の程度は症例によってさまざまであるため，十分なデブリドマンの後，①胸骨閉鎖，②VAC，③大網充填などを組み合わせて対応していくことが肝要である．

V. 結　論

心臓血管外科手術後の感染を予防するためには，以下のことを日々実践していくことが肝要である．

1) ガイドラインに沿って各施設，各診療科ごとの「感染対策マニュアル」を作成し，感染予防に努める．

2) 予防的抗菌薬は cefazolin または ampicillin と sulbactam の合剤を用い，手術開始前に投与し術後 48 時間で終了とする．

3) 術後感染症が疑われた場合には，必ず各種細菌培養検査を行ってから抗菌薬を投与する．

4) 縦隔炎が疑われた場合にはただちに CT を撮影し，外科的治療を開始する．症状に応じて vacuum-assisted system を用いた持続陰圧吸引療法を行う．

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SUMMARY

Management of Mediastinitis and Preventions of Perioperative Nosocomial Infection after Cardiovascular Surgery

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This article reviews risk factors and treatment of perioperative nosocomial infections. The primary prophylactic antibiotic is recommended to be a cefazolin or penicillin with sulbactam, because the most frequent organism cultured in cardiac surgical site infection (SSI) is *Staphyloccocus*. Antibiotic prophylaxis of 48 hours' duration after cardiovascular surgery is clinically effective in minimizing infectious complication. In patients considered at high risk for a staphylococcal infection, vancomycin may be recommended. In the treatment of postoperative infections, Gram-stain-based antibiotic selection is necessary and the initial empirical therapy to ensure adequate coverage of potentially infective organisms should be accompanied by de-escalation until microbiological data become available. Mediastinitis, which is one of the important infectious complications after cardiovascular surgery, requires surgical drainage and debridement, as well as antimicrobial therapy. Vacuum-assisted closure (VAC) is an effective therapy compared with the conventional technique of open packing. Continuous clinician's efforts and prolonged infection control programs are very important for prevention of perioperative nosocomial infection after cardiac surgery.

————————————————————————————KEY WORDS
cardiovascular surgery/antibiotic prophylaxis/mediastinitis/risk factor

未破裂の心外型 Valsalva 洞動脈瘤

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── はじめに ──

Valsalva 洞動脈瘤はまれな疾患であり，その未破裂例はさらにまれである．未破裂例は無症状で偶然発見されるために，その治療方針は議論のあるところである．今回，未破裂の心外型 Valsalva 洞動脈瘤を経験したので報告する．

── I. 症　　例 ──

症　例　49歳，女．
主　訴：労作時息切れ．
家族歴：特記すべきことはない．
既往歴：36歳時に子宮腺筋症，慢性閉塞性肺疾患．
現病歴：2005年1月ごろから労作時息切れを自覚し，当院内科を受診した．慢性閉塞性肺疾患として外来治療していたが，2007年9月にたまたま施行した心臓超音波検査で Valsalva 洞動脈瘤を指摘され，手術目的にて当科へ紹介となった．
現　症：身長160 cm，体重41.2 kg，体温36.8℃，血圧136/76 mmHg，脈拍60回/分・整であった．心雑音はなかった．漏斗胸と両下肢静脈瘤を認めた．
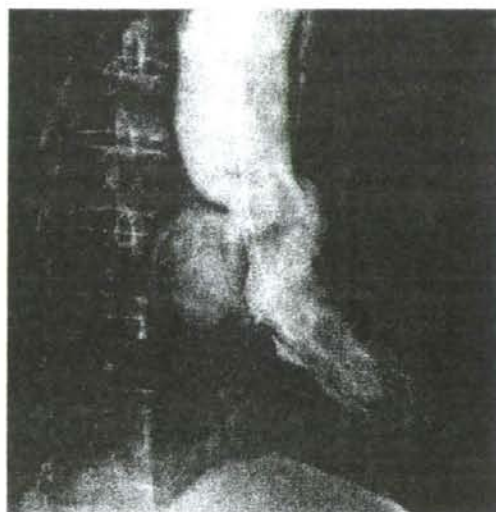**血液・生化学所見**：血液一般，生化学，血清検査はすべて正常で，炎症反応も陰性であった．

図1. 術前左室造影像
無冠状動脈洞の瘤化を認める．

胸部X線所見：心胸郭比45.7%，肺気腫様変化を認めた．
呼吸機能所見：1秒率48.2%，%肺活量92%であった．
心電図所見：洞調律，不完全右脚ブロックを認めた．
心臓超音波所見：無冠状動脈洞に3.5×4.2 cmの動脈瘤を認めた．左室駆出率は77%と良好で，

図2. 術中所見
無冠状動脈洞に 20×15 mm の瘤口があり，
その右側に瘤を認める.

図3. 術後 CT
無冠状動脈洞動脈瘤の血栓化（矢印）
を認める.

大動脈弁閉鎖不全を認めなかった.

心カテーテル所見：無冠状動脈洞から生じた巨
大な Valsalva 洞動脈瘤を認めた（図1）.

以上から無症状であるものの，巨大瘤破裂の危
険性を考慮して手術適応とした.

手術所見：胸骨正中切開にて開胸した. Val-
salva 洞動脈瘤は心内腔と接しない心外型であっ
た. 上行大動脈送血，上下大静脈脱血にて人工心
肺を確立した. 上行大動脈を遮断し，右上肺静脈
ベントを行いながら心筋保護液を順行性および逆
行性に注入して心停止を得た. 上行大動脈を横切
すると無冠状動脈洞に 20×15 mm の瘤口を認め
た（図2）. ウマ心膜パッチ（XAG-400：Edwards
Lifesciences 社，Irvine）を用い，5-0 プロリン
糸の連続縫合で瘤口を閉鎖した. 人工心肺からの
離脱は容易であった.

術後経過：術後は順調に経過し，CT で瘤の血
栓閉塞を確認した（図3）.

────── **II. 考　　察** ──────

Valsalva 洞動脈瘤は井上[1]の分類が一般的に用
いられ，心外型と心内型に分類される. 心外型は
通常1個の Valsalva 洞から発生した囊状動脈瘤
であり，心外に発育してしばしば巨大化するが，
右心房を外から圧迫することはあっても右心房内
に突出することはない. 一方，心内型は瘤口を有
する瘤が心腔内に突出するが，通常みられる破裂
性の瘤では小指頭ないし母指頭大で，wind-
sock, balloon type と表現されるように吹き流し

状あるいは指サック状を呈し，その先端が穿孔す
ることが特徴とされる[1].

Valsalva 洞動脈瘤の原因は先天性と後天性に
分けられる. 先天性としては胎生期の円錐部隆起
および心内膜床の融合不全や Marfan 症候群など
の中膜変性によるものが考えられ，後天性として
は外傷，大動脈炎症候群，梅毒，結核などによる
ものが考えられる[2,3]. 心外型の原因は大動脈壁
と大動脈弁輪間の中膜の連続性が欠如しているこ
とであり[4]，心内型はこれに中隔筋性組織の欠損
が加わるとする説[5]があり，合理的な説明である
と考えられる.

本稿では特に心外型について述べることにす
る. 本邦ではこれまでに文献上20例の心外型
Valsalva 洞動脈瘤が報告されている（表1）. 平
均年齢51.5（24～69）歳，男女比は 10：10 と同
等であった. 主訴は合併する心疾患によるものが
多く，14例（70%）に大動脈弁閉鎖不全症，8
例（40%）に冠状動脈病変，このほかに右室流
出路狭窄2例，上行大動脈瘤2例を認めた. 瘤
の発生部位は左冠状動脈洞5例，右冠状動脈洞7
例，無冠状動脈洞6例とほぼ同等の比率であっ
たが，すべての冠状動脈洞に認めたものが1例，
右～無冠状動脈洞に発生したものが1例あった.

表1 本邦における未破裂の心外型 Valsalva 洞動脈瘤の報告例

報告者 年	瘤径(mm)	瘤の部位	合併心疾患	手術
（1985）	60	L	AR, LMT 圧迫	パッチ閉鎖, AVR
（1987）	100	N	上行瘤	パッチ閉鎖＆上行置換術
（1989）	100	R	AR, RCA 閉塞	パッチ閉鎖
（1989）	80	L	AR, LMT 閉塞	パッチ閉鎖, AVR, CABG
加藤 （1993）	30	R	AR, 右室流出路狭窄, 狭心症	パッチ閉鎖, AVR, CABG
Okita （1995）	70	R	RCA 圧迫	パッチ閉鎖, RCA 再移植
浜田 （1995）	70	N	AR	パッチ閉鎖
水島[7] （1996）	140	R	なし	パッチ閉鎖, 瘤縫縮
本多 （1997）	60	R-N	AR	パッチ閉鎖, AVR
Yasuda[8] （2000）	70	L	AR, RCA 拡張症	大動脈基部置換術
	50	N	AR, 上行瘤	パッチ閉鎖, 上行置換術
下山 （2001）	80	R	AR, RCA 閉塞	パッチ閉鎖, AVR, CABG
Kusuyama[9] （2002）	15	R	AR	パッチ閉鎖
佐藤 （2002）	35	N	なし	パッチ閉鎖, 瘤切除
横山 （2003）	50	L	RCA 瘤	パッチ閉鎖, CABG
内川[6] （2003）	35	N	AR	パッチ閉鎖, AVR→出血：上行置換術
近江 （2004）	66	L	AR	大動脈基部置換術
石神 （2004）	70	R	AR, 右室流出路狭窄	パッチ閉鎖, AVR, CABG
Akashi （2005）	60, 42, 20	N, L, R	AR	大動脈基部置換術
木村[10] （2006）	52	N	なし	大動脈基部置換術

L：左冠状動脈洞, R：右冠状動脈洞, N：無冠状動脈洞, AR：大動脈弁閉鎖不全, RCA：右冠状動脈, LMT：左冠状動脈主幹部, AVR：大動脈弁置換, CABG：冠状動脈バイパス術

瘤径は 15～140 mm とさまざまであった. 手術術式は 16 例 (80%) でパッチ閉鎖が行われており, これに合併心疾患に対する AVR や CABG が追加されていた. パッチ使用例の中には閉鎖部位からの出血のため上行置換へ変更した症例もあった[6]. パッチ閉鎖が困難な 4 例に対しては大動脈基部置換術が行われた.

病理組織学的に動脈瘤壁が特異的所見を示したのは 5 例あったが (Ehlers-Danlos 症候群, 好酸球増多症候群, Marfan 症候群, Behçet 病, 大動脈炎症候群)[7~10], 動脈瘤様変化の所見が 8 例と多く, ほかに粘液腫様変性が 2 例, 記載なしが 5 例であった.

手術術式はパッチ閉鎖術が標準と思われるが, 合併心疾患や Valsalva 洞動脈瘤の性状, 上行大動脈の性状を考慮して決定すべきであろう. 手術適応については議論のあるところである. 本症はまれな疾患であり, 動脈硬化性動脈瘤のような瘤径に基づいた手術適応基準はない. 本症の原因が大動脈壁と大動脈弁輪の中膜の連続性の欠如であることから, 瘤破裂のリスクは高いと考えられる. 本症の報告例中, Behçet 病に伴った Valsalva 洞動脈瘤では瘤径 15 mm で手術が施行されて

いた[9]. 合併疾患を考慮しながら, 発見後早期の手術が望ましいと考えられた.

本例は大動脈壁や瘤壁を採取していないため病理組織学的検討ができず, Valsalva 洞動脈瘤の原因確定にはいたらなかった.

─── おわりに ───

未破裂の心外型 Valsalva 洞動脈瘤の 1 例に対して瘤口パッチ閉鎖術を行い, 良好な結果を得た.

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SUMMARY

Surgical Repair of Extracardiac Unruptured Aneurysm of the Sinus of Valsalva

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An isolated extracardiac unruptured aneurysm of the non-coronary sinus of Valsalva was detected incidentally in a 49-year-old woman with chronic obstructive pulmonary disease.

The orifice of the aneurysm was closed with XAG-400 patch. The aortic valve was normal. 20 cases of successful operation have been reported in Japan with extracardiac unruptured aneurysm. In the review of the literature, patch closure of the orifice of the aneurysm was the standard procedure in most cases. However, aortic root replacement was required in some cases with concomitant cardiac and/or aortic disease.

——————————————————————————————————————KEY WORDS

aneurysm of sinus of Valsalva/extracardiac aneurysm/patch closure

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