器機能障害，あるいは心臓機能障害と腎臓機能障害の合併が多い．これも人口高齢化の加速や動脈硬化性疾患の増加によるものと考えられよう．すなわち，臓器別リハや運動機能の回復のみのリハを行って安穏としているだけでは，リハ診療として不十分な時代に突入したのである．

重複障害がある場合は，臓器別リハのFITTを見直さなくてはならない．たとえば，変形性膝関節症に慢性心不全を合併している場合，運動療法の中止基準は心不全のものに従い幾分マイルドな運動にとどめる必要がある，などである[1]．

4. 治療期ステージからの面

治療期ステージからみた場合は，心臓リハの場合は，急性期リハ・回復期リハ・維持期リハというように分類できよう．しかし，急性期・回復期・維持期リハの定義は，疾患群により異なる．例えば，脳卒中リハにおいての急性期リハは，発症後ベッドサイドリハを開始してから，車椅子に15～30分ほど坐れてリハ室での訓練が可能になるまで，回復期リハは，リハ室での訓練が開始され，在宅あるいは施設に入るようになるまで，維持期は在宅あるいは施設に入ってからというように定義している．

さらに，リハの有効性が治療期ステージで異なることも重要である．心臓リハを例にとれば，心筋梗塞患者で確実に生命予後改善を果たすのは，短期間の急性期の心臓リハではなく，回復期心臓リハであることが明らかになっている[4]．すなわち，リハの早期からの介入が叫ばれているが，早く短期間にやればそれで済むわけでもなく，適切な内容のリハを適切な時期に行うことが極めて重要なのである[4,5]．

5. ライフステージからの面

ライフステージからみた場合は，医学的リハ，教育的リハ，職業リハ，社会的リハというように分類できよう．医学的リハでは，主として，機能障害の回復や機能的制限の軽減をはかり，適応能力の向上を促す．職業リハでは，機能的制限のため失職者や未就業者が職を得ることを支援する（職業指導，職業訓練，職業あっせん，保護雇用，追跡指導）．教育的リハでは，心身に機能障害のある児童に対して，知的教育や人間全体の総合教育を行う．社会的リハは，医学的，職業および教育的リハの全過程が円滑に進行するように，経済的条件や社会的条件を調整するためのサービスである[6]．

まとめ

心臓疾患の患者が重複障害を有するという理由で，リハに加われない場合も少なくないとされている．重複障害の時代における心大血管疾患リハは，そもそも包括的に行われるべきものである．包括的リハはリハプログラムのみにとどまらず，チームメンバー，障害内容，治療期ステージ，ライフステージの面からも考慮されなければならない．リハ従事者はこのような重複障害のリハに携わる知識と経験を有する必要があるとともに，多くのリハ関連職種や他分野との連携がますます重要になってくる．同時に，今後も様々の課題に取り組み，時間的・経済的・内容的にさらに魅力的な患者主体の新しいプログラム・システムの作成を行う必要があろう[7]．

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パネルディスカッション５

日本の心臓リハビリテーションの現状と将来：わが国における心臓リハビリテーションの問題点

Issues of Cardiac rehabilitation in Japan

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抄　録

心臓リハビリテーション（心臓リハ）は多くの研究によりその有用性が確認され，循環器疾患に対する「有効な治療」としての地位を確立した．心臓リハは，わが国の厚生労働省が推進している４疾患・５事業の「心筋梗塞」治療ならびに再発予防の重要な要素でもあるが，著しく普及が遅れている．その主な要因に，施設基準の厳しさ，採算性の問題がある．循環器病研究委託費（15–指２）研究班の調査では，年間AMI入院患者数が平均値（48例）の施設での心リハの参加患者数は１日3～5例にすぎないことが明らかになった．この少数の症例のためにリハ従事者１名を「専従」で配置したり，循環器科または心臓血管外科の医師が常時勤務することは不経済である．当学会では，平成22年度の診療報酬改訂に備え，①トレッドミルまたはサイクルエルゴメータによる負荷心肺機能検査における連続呼気ガス分析加算，②心大血管疾患リハビリテーション料に関わる施設認定基準の見直しを，他学会と協力して要求している．平成22年度の診療報酬改訂に期待するとともに，心臓リハのエビデンスを患者・医療関係者双方に周知徹底させ，患者・医療関係者への心臓リハ，特に回復期心臓リハの重要性の啓蒙することが心臓リハの普及に欠くことができないと考えられる．

〔心臓リハビリテーション（JJCR）15（1）：72-74，2010〕

Key words：心臓リハの普及，普及の阻害因子，施設認定基準，診療報酬改訂

はじめに

心臓リハビリテーション（心臓リハ）は多くの研究によりその有用性が確認され，循環器疾患に対する「有効な治療」としての地位を確立した．心臓リハは，わが国の厚生労働省が推進している４疾患・５事業の一つである「心筋梗塞」治療ならびに再発予防の重要な要素である．本稿では心臓リハのわが国での現状と問題点を明らかにし，今後の対策を提言する．

心臓リハの有用性に関するエビデンス

心臓リハは「医学的な評価，運動処方，冠危険因子の是正，教育およびカウンセリングからなる長期的で包括的なプログラムである．このプログラムは，個々の患者の心疾患に基づく身体的・精神的影響をできるだけ軽減し，突然死や再梗塞のリスクを是正し，症状を調整し，動脈硬化の過程を抑制あるいは逆転させ，心理社会的ならびに職業的な状況を改善することを目的とする」と定義されている[1]．すなわち，脳卒中リハのように，単に在宅生活や復職をゴールとするのではなく，再発防止や生命予後の延長までをめざすものである．

従来のリハといえば「疾病罹患後の廃用症候群の回復」というイメージが強かったが，多要素プログラムを擁する包括的回復期心臓リハにより，「日常生活動作の自立と社会復帰」，「要介護の軽減」のみならず，冠動脈硬化・冠循環の改善，冠危険因子の是正，生命予後の改善，機能予後の改善，QOLや不安・鬱の改善などの目覚ましい成果がもたらされた[2]．すなわち，リハに「危険因子の軽減による攻めの医療」という概念が加わった[3]．米国心臓学会のガイドラインでは心筋梗塞患者の

表1　平成22年度診療報酬改訂への要望事項

1. 心臓リハビリ担当の理学療法士が他のリハの担当できない！
   ⇒心臓リハ患者がいない時は脳卒中や運動器疾患患者のリハもできたほうが良い
   ⇒医療職専従・専任要件の緩和
   a) 医療職（常勤看護師・理学療法士）の専従要件を専任に緩和
   b) 心大血管リハ専任理学療法士が他のリハの専従を禁止している点を撤廃
   c) 専任医療職として医師の直接監視下を条件に臨床検査技師の追加

2. 施設Ⅰにおいて循環器・心臓血管外科医師の「常時勤務」（24時間，365日勤務）が必要である！
   ⇒リハビリの時に勤務していれば十分
   ⇒「常時勤務」から「常勤」へ変更

3. 心臓リハビリ専用の機能訓練室が必要である！
   ⇒リハビリ室に専用スペースが確保されていれば良い
   ⇒機能訓練室の面積要件を「部屋」から「場所（スペース）」として確保への変更

4. 連続呼気ガス分析に点数がついていない！
   ⇒適切な運動処方のための検査に点数が必要
   ⇒心肺運動負荷試験施行時の連続呼気ガス分析加算

長期予後を改善する方法として，回復期・維持期には，心臓リハがスタチン（高脂血症治療薬）と並んでクラス1（確実に有効なもの）として挙げられているほどである[4]．

わが国での心臓リハ普及率

厚生労働省循環器病研究委託費「わが国における心疾患リハビリテーションの実態調査と普及促進に関する研究」班（後藤葉一班長）で，わが国における心臓リハの実態について全国調査を2004年に実施した[5]．その結果，循環器専門医研修施設の97％が急性心筋梗塞（AMI）入院を受け入れ，90％以上の施設が冠動脈造影，PCI，緊急PCIを実施していたのに対し，心臓リハ実施率は明らかに低かった．すなわち「AMIに何らかのリハビリを実施している」「AMIに急性期心臓リハを実施している」施設は約半数，「AMIに回復期心臓リハを実施している」施設は20％，「外来通院型心臓リハを実施している施設」は9％にすぎなかった．日米の人口や冠動脈疾患発生率の差を考慮しても，わが国における外来通院型心臓リハ実施施設の少なさが目立つ．

わが国での心臓リハプログラム内容

さらに同じ調査で心臓リハの内容に関して検討したところ，「心臓リハ患者教育プログラム」「運動耐容能検査に基づく運動処方」「呼気ガス分析による心肺運動負荷試験（CPX）」など，心臓リハのガイドライン[2]で推奨されている重要な診療内容を実施している施設の比率は低かった．心臓リハは，単に心電図監視下で身体運動トレーニングのみを実施すればよいというものではない．心臓リハは二次予防教育や運動負荷試験に基づく適切な運動強度の設定などを含む包括的患者マネジメントである．運動療法だけでは禁煙効果はほとんどなく，また，脂質・肥満・血圧には効果が一定していないなど，再発予防のための危険因子の軽減が十分ではないことは周知の事実である[1]．今後のわが国の心臓リハは，単なる運動療法のみならず，教育や心理的ケアなど多要素的に包括的心臓リハとして行われるよう徹底する必要がある．

わが国での心臓リハ普及の阻害因子

AMIに対する心臓リハを実施していないと回答した循環器専門医研修施設における心臓リハを実施しない理由を調査したところ，その三大理由は「スタッフ不足」「設備がない」「施設基準を取得していない」であった[5]．これらの背景要因には，施設基準の厳しさと採算性の問題があると考えられる（表1）．

すなわち，施設基準を取得するためには条件を満たしたスタッフが必要であり，これには，心臓リハ担当の理学療法士が他のリハの担当ができない制度になっていること，運動負荷試験やリハの場面で機器の扱いや心電図の解釈に威力を発揮する臨床検査技師が，診療報酬上はスタッフとして認められていないこと，また，施設Ⅰの基準において循環器・心臓血管外科医師の常時勤務が必要であることなど，人件費の面で問題になり，スタッフを雇用できずに実施に至らない場合が多い．実際，循環器病研究委託費（15−指2）研究班の調査では，年間AMI入院患者数が平均値（48例）の施設での心リハの

参加患者数は1日3～5例にすぎない[6]．この少数の症例のためにリハ従事者1名を「専従」で配置したり，循環器科または心臓血管外科の医師を常時勤務させることは不経済である．一方，施設基準を取得するための設備の面に関しては，心臓リハビリ専用の機能訓練室が必要であることがネックになっている．また，適切な運動処方のための検査に高価な連続呼気ガス分析装置が必要であるが，心肺運動負荷試験施行時に連続呼気ガス分析加算がついておらず，採算面で厳しいことが挙げられる．さらに，心臓リハのエビデンス自体が患者・医療関係者双方で十分周知徹底されていないことも，心臓リハの普及を阻害する大きな要因の1つであると考えられる．

わが国での今後の対策

以上のような現状分析を基に，当学会では診療報酬対策委員会を中心に，他学会と協力して，平成22年度の診療報酬改訂に備え，①トレッドミルまたはサイクルエルゴメータによる負荷心肺機能検査における連続呼気ガス分析加算，②心大血管疾患リハビリテーション料に関わる施設認定基準の見直しを要求しているところである(表1)．

同時に，心臓リハのエビデンスを患者・医療関係者双方に周知徹底させ，患者・医療関係者への心臓リハ，特に回復期心臓リハの重要性の啓蒙することが重要である．また，患者自身が自立・継続してリハを行えるようにする工夫が必要である．さらに，リハの効果を維持するためには継続が必要不可欠であり，フォローアップのシステムをつくり継続させるような方策をとることが望ましい．

おわりに

心臓リハのゴールは単に自宅退院，ADLの自立，復職のみにあるのではない．この点が脳卒中リハなどと大きく異なる点である．すなわち，心臓リハは，長期的な包括的リハによる原疾患の再発防止，生命予後の改善，動脈硬化性疾患の予防・治療，動脈硬化巣そのものの改善など，「攻めの医療」としての役割も担っている．心臓リハの効果を最大限に享受するためには，患者が生活習慣を改善し，自宅退院後に十分な運動量を確保し，食事療法や薬物療法を自発的かつ長期的に自信をもって行えるように指導することが肝要である．解決すべき課題も多いが，心臓リハは今後ますます重要な「不可欠の治療」となると考えられる．平成22年度の診療報酬改訂に期待するとともに，心臓リハの有する様々な課題に取り組み，時間的・経済的・内容的に，さらに魅力的な患者主体の新しいプログラム・システムの作成を行う必要もあろう．

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Improvement of Cardiorespiratory Capacity for Patients with Severe Heart Failure after LVAS Implantation

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Summary

The purpose of this study was to evaluate the trainability of left ventricular assist system (LVAS) patients during long-term aerobic exercise training. 14 (39.0+/-9.7 years old , LVEF 20.5+/-8.1%) end-stage severe heart failure patients who underwent LVAS implantation participated in aerobic exercise training program using cycle ergometer. Before the training (A) and 1 month (B) and 3 months (C) after the beginning of exercise training, peak oxygen uptake (VO_2) (12.2+/-2.8(A), 14.3+/-3.3(B), 15.3+/-3.5(C) mL/kg/min; p=0.044) increased significantly. The differences of blood lactate concentration between at rest and the 40watt during exercise stress test showed significantly decrease (0.9+/-0.8(A), 0.4+/-0.4(B), 0.3+/-0.3(C) mmol/L ; p=0.022). These findings suggest that peripheral skeletal muscle metabolism can ameliorate though cardiac function of these LVAS patients showed no significant increase after LVAS implantation.

Introduction

Despite being an established procedure for the treatment of end-stage heart failure, heart transplantation is limited by the scarcity of donor heart. In Japan due to the extreme shortage of donor hearts, heart failure patients must wait for heart transplantation for about 2 years on average with left ventricular assist system (LVAS) support in their hospitals [1]. Furthermore the only commercially available device in Japan has been the Toyobo LVAS, which is a paracorporeal pneumatic-type LVAS and has a smaller pulsatile flow than other types of devices.

Cardiac rehabilitation for patients who received LVAS is very important because those patients have extreme low level exercise capacity due to severe heart failure [2]. And these patients are required improvement and maintenance of their cardiorespiratory capacity in order to get a better outcome of heart transplantation.

A retrospective review of survival data in patients with LVAS showed that progres-

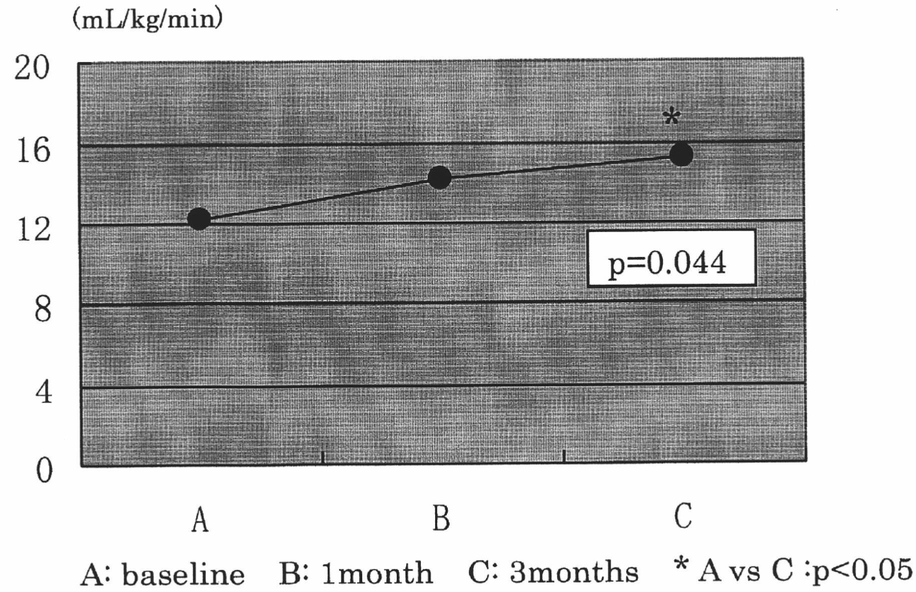

Fig A Peak VO_2 before and during exercise training

sive mobilization in these patients was safe and patients could return to independence in activities of daily living and tolerate prolonged workloads of up to 5 metabolic equivalents [3]. But the improvement of cardiorespiratory capacity of these patients after long-term cardiac rehabilitation was not to be elucidated. The purpose of this study was to evaluate the trainability of LVAS patients for long-term exercise training.

Materials and Methods

14 (39.0+/-9.7 years old , male/female 12/2, DCM / fulminant myocarditis / ischemic cardiomyopathy 11/1/2, LVEF 20.5+/-8.1%) end-stage severe heart failure patients who received LVAS (Toyobo Ltd. Japan) participated in exercise training program using cycle ergometer at the intensity of AT (anaerobic threshold : 68.5+/-11.1 % of peak VO_2) level. Endurance exercise training was carried out 3-5 times weekly for 30 minutes. Before the training (A) and 1 month (B) and 3 months (C) after the beginning of exercise training, symptom-limited cardiopulmonary exercise testing (CPX) was done in order to evaluate peak VO_2, peak watt and AT. During CPX capillary blood was taken for the measurement of blood lactate concentration every one minute.

CPX was performed using cycle ergometer (Strength Ergo8, Mitsubishi Engineering Co. Ltd, Japan) by 15watts/min ramp protocol with 4 minutes warming-up at 0watt. During exercise test ECG and blood pressure ware monitored. Gas exchange parameters ware determined by the metabolic gas analyzer (AE-300S, Minato Medical Science Co. Ltd, Japan) and an assay for blood lactate concentration was performed by lactate analyzer (Lactate Pro, Arkray Co.Ltd, Japan).

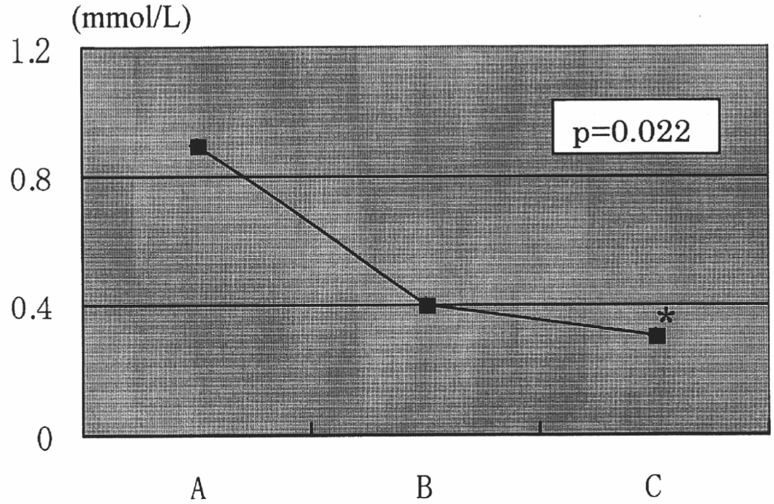

Fig B The differences of blood lactate levels between at rest and the 40watt during exercise stress test

Results

Peak VO_2 (12.2+/-2.8(A), 14.3+/-3.3(B), 15.3+/-3.5(C) mL/kg/min; p=0.044 ANOVA, FigA) and peak workload (53.4+/-10.9(A), 69.71+/-15.2(B), 76.9+/-17.1(C) watt; p=0.0004) increased significantly during training period. The differences of blood lactate concentration between at rest and the 40watt during exercise stress test showed significantly decrease (0.9+/-0.8(A), 0.4+/-0.4(B), 0.3+/-0.3(C) mmol/L ; p=0.022, FigB). The improvement of peak VO_2 between A and B was 17.5% and between B and C was 7.6% respectively.

Conclusions

The improvement of exercise capacity of LVAS patients is detected by long-term aerobic exercise training. These findings suggest that peripheral skeletal muscle metabolism can ameliorate though cardiac function of these LVAS patients shows no significant increase after LVAS implantation.

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Effect of Tai Chi Training on Baroreflex Sensitivity and Heart Rate Variability in Patients With Coronary Heart Disease

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SUMMARY

Tai Chi is a traditional Chinese conditioning exercise that has been used to integrate slow movements, controlled breathing, and mental concentration. The aim of the study was to determine whether Tai Chi training in addition to cardiac rehabilitation would result in a shift toward increased vagal activity of autonomic markers, such as baroreflex sensitivity (BRS) and heart rate variability (HRV). Twenty patients with coronary heart disease (CHD) (male/female: 13/7, mean age: 67.8 ± 4.2 years, mean interval time after a coronary event: 19.8 months) completed this study. The Tai Chi group (n = 10) practiced supervised Tai Chi training once a week and home-based Tai Chi training three times a week together with conventional cardiac rehabilitation for one-year. The control group (n = 10) conducted the conventional cardiac rehabilitation only. BRS and HRV were evaluated at the baseline and after one-year of Tai Chi training. Compared with the controls, patients in the Tai Chi group showed statistically significant improvement in BRS (P = 0.036). These associations persisted after adjustment for age and other covariates. On the other hand, there were no significant trends seen in HRV. Additional Tai Chi training during cardiac rehabilitation may augment reflex vagal regulation, which adds importantly to knowledge of cardiac rehabilitation on autonomic regulation and clinical management of CHD. (Int Heart J 2010; 51: 238-241)

Key words: Cardiac rehabilitation, Coronary heart disease, Exercise, Alternative medicine, Autonomic regulation, Vagal activity

Tai Chi is a traditional Chinese conditioning exercise that has been used to integrate slow movements, controlled breathing, and mental concentration. Regular Tai Chi training has been shown to improve health by improving cardiorespiratory fitness, balance, and flexibility[1)] and cardiovascular risk factors.[2,3)] Tai Chi is effective and safe even for patients with coronary heart disease and heart failure.[4,5)] In addition, a recent article review suggested potential benefits from Tai Chi performed as an adjunct to cardiac rehabilitation exercise training.[6)]

Both an attenuated baroreflex sensitivity (BRS) and heart rate variability (HRV), which are thought to be markers of reflex and tonic vagal regulation, are predictors of mortality in patients with coronary heart disease (CHD).[7)] Many studies have shown that cardiac rehabilitation exercise training improves cardiac autonomic regulation in these patients by reducing sympathetic activity and/or increasing parasympathetic tone both in humans and laboratory animals.[8,9)] A relationship between changes in autonomic balance and survival following exercise training after myocardial infarction has also been demonstrated at the experimental and clinical level.[10,11)]

It has been suggested that the health benefit of Tai Chi may be the outcome of a process that influences the endogenous neuro-hormonal feedback mechanism.[12)] Indeed, Tai Chi has been shown to increase HRV and decrease sympathetic activity in both young and old male subjects.[13)] However, to the best of our knowledge, the effect of Tai Chi on cardiac autonomic regulation in CHD patients has not been reported. In this study, we tested the hypothesis that Tai Chi training in addition to cardiac rehabilitation would accelerate an improvement in BRS and HRV in patients with CHD.

METHODS

Participants and study design: A total of 20 patients with CHD (male/female: 13/7, mean age: 68 ± 4 years, mean interval time after a coronary event: 20 ± 14 months) were recruited from the Cardiac Rehabilitation Center of our hospital in Japan, and were randomized to one year of Tai Chi training in addition to their usual care or to a control group. Inclusion criteria were 1) ejection fraction > 40% and 2) clinical stability defined as no major changes in pharmacological therapy in the previous 3 months. Exclusion criteria were atrial fibrillation or abnormal sinus node function, unstable angina pectoris, and resting arterial blood pressure > 170/100.

The Tai Chi training group (n = 10) practiced supervised group Tai Chi training once a week and home-based Tai Chi training three times a week together with routine care for one year. Routine care included pharmacological therapy, dietary

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guidance, and physical activity counseling in accordance with the Japanese Circulation Society guidelines.[14] The control group (n = 10) carried out the routine care only. This study was conducted in accordance with the Declaration of Helsinki and all patients provided informed, written consent.

Intervention: The supervised Tai Chi training session included 10 minutes of warm-up exercises, 45 minutes of Tai Chi practice, and 5 minutes of cool-down exercises. The 8 core movements, adapted from classical Yang-style Tai Chi, were chosen for promoting overall relaxation of the body and mind. During Tai Chi exercise, the patient group was led by an instructor and they imitated the motion at the same speed. Their heart rate (HR) during Tai Chi practice was 40-50% of the heart rate reserve. In addition, a 20-minute instructional videotape outlining Tai Chi movement was presented to each patient. Furthermore, the patients were encouraged to practice individually at home at least three times per week.

Equipment and measurement: BRS and HRV were evaluated at the baseline and after one-year of Tai Chi training. Patients carried out the measurements in the morning between 9:00 and 10:00. Measurements of spectral analysis were performed in a seated upright position for a 60 second time series during paced breathing (0.25 Hz) after 15 minutes of rest. Instantaneous systolic blood pressure (SBP; Jentow 7700, Colin, Tokyo) and R-R intervals (interval between successive R waves of the ECG) were continuously recorded. The fluctuations in SBP and R-R intervals were integrated on two component bands, the high-frequency band (HF: 0.15 to 0.40 Hz) and the low-frequency band (LF: 0.05-0.15 Hz). The BRS was calculated as the square root of the ratio of R-R interval power and SBP power in the LF band for values of coherence of 0.5 or greater.[15,16] The HRV was evaluated using auto-spectral analysis of R-R intervals and expressed as the power of the LF (HRV-LF) and HF (HRV-HF) components and the low-/high-frequency power ratio (HRV-LF/HF).[17]

To assess aerobic fitness, cardiopulmonary exercise testing (CPX) was performed in the upright position on a bicycle ergometer (Strength Ergo 8, Fukuda Denshi, Tokyo) with an initial workload of 0 watts (W), with subsequent increments of 15 W every minute until exhaustion. Expired gas exchange during symptom-limited exercise testing was measured by breath-by-breath analysis with a metabolic cart (AE300s, MINATO, Tokyo). From these measurements, oxygen uptake was calculated every 10 seconds.

Statistical analysis: All values are expressed as the mean ± standard deviation. Differences between groups in the baseline characteristics were assessed using the t test or χ^2 test as appropriate (SPSS 16.0J for Windows, SPSS Inc., Chicago, USA). A repeated two-way ANOVA was used to compare the effects of Tai Chi training versus the control on changes in outcome during the study period. A value of $P < 0.05$ was regarded as significant.

Results

All of the 20 enrolled patients fully completed the study. During the study period, medical treatment was maintained almost constant, and no clinical events were recorded. There were no significant changes in the daily physical activity in all patients during the study period.

The baseline characteristics of the study population are given in Table I. No differences were observed between the Tai Chi participants and the control patients with respect to demographic, clinical, and functional characteristics, except for body mass index (BMI) which was significantly higher among the Tai Chi group than among the controls.

Table II shows the changes in BRS and frequency domain HRV indices during the study period. Tai Chi participants showed a significant improvement in BRS (from 5.9 ± 5.0 to

Table I. Baseline Characteristics of the Study Participants

Characteristic	Tai Chi (n = 10)	Control (n = 10)	P
Age (years)	68 ± 5	68 ± 4	0.96
Male sex	6	7	0.64
Body mass index (kg m^{-2})	26 ± 8	23 ± 2	0.03*
Ejection fraction (%)	59 ± 8	68 ± 13	0.09
Myocardial infarction	5	6	0.65
CABG	8	7	0.61
Months after onset (months)	19 ± 15	21 ± 13	0.73
Peak oxygen up take (L min^{-1})	1.0 ± 0.2	1.2 ± 0.4	0.42
Heart rate (beats min^{-1})	70 ± 13	68 ± 9	0.65
Systolic BP (mmHg)	135 ± 14	122 ± 18	0.09
Medication			
Beta-blocker	7	4	0.18
Angiotensin-coverting enzyme inhibitor	4	5	0.65
Angiotensin II antagonist	1	0	0.31
Ca-antagonist	2	3	0.61
Nitrate	2	3	0.61
Cardiovascular-related risk factor			
Hypertension	6	9	0.12
Diabetes	6	2	0.07
Hyperlipidemia	5	7	0.36
Smoking	0	0	1.00

Values are mean ± SD or numbers, $*P < 0.05$

Table II. Results at Baseline and One Year After Tai Chi Training

	Tai Chi (n = 10)		Control (n = 10)		$P^{\#}$
	Baseline	1 year after	Baseline	1 year after	
Peak oxygen uptake (L min^{-1})	1.0 ± 0.2	1.1 ± 0.3	1.2 ± 0.4	1.2 ± 0.3	0.80
Heart rate (bpm)	70 ± 13	66 ± 10	68 ± 9	67 ± 9	0.38
Systolic blood pressure (mmHg)	135 ± 14	129 ± 12	122 ± 18	130 ± 16	0.11
BRS (ms/mmHg)	5.9 ± 5.0	8.1 ± 5.4	6.9 ± 3.8	5.4 ± 4.2	0.04*
Heart rate variability (HRV)					
LF power (ms^2)	326 ± 496	310 ± 540	161 ± 152	182 ± 172	0.72
HF power (ms^2)	99 ± 237	117 ± 269	54 ± 92	66 ± 102	0.78
LF/HF power ratio	17 ± 27	12 ± 12	7.8 ± 9	16 ± 29	0.38

BRS indicates baroreflex sensitivity, LF indicates low-frequency, and HF indicates high-frequency. # To compare the group differences between the Tai Chi group and the control group. * $P < 0.05$

8.1 ± 5.4 ms/mmHg, P = 0.036) while no significant change was observed in the control patients (from 6.9 ± 3.8 to 5.4 ± 4.2 ms/mmHg). These associations remained significant even after adjustment for age, gender, ejection fraction, and BMI. The changes in the power of the HRV-LF (from 326 ± 496 to 310 ± 540 versus 161 ± 152 to 182 ± 172 ms^2, ns), HRV-HF (from 99 ± 237 to 117 ± 269 versus 54 ± 92 to 66 ± 102 ms^2, ns), and HRV-LF/HF (from 17 ± 27 to 12 ± 12 versus 7.8 ± 9 to 16 ± 29, ns) did not differ between the groups.

Discussion

We evaluated the additional effects of Tai Chi training during cardiac rehabilitation on BRS and HRV in patients with CHD. One-year treatment was found to result in a significant increase in BRS in the Tai Chi group while no changes were observed in the control group. On the other hand, there were no significant trends seen in frequency domain HRV indices. These observations suggest that regular Tai Chi training can augment reflex vagal regulation without a corresponding increase in tonic vagal modulation. To the best of our knowledge, this is the first study showing the potential benefits from Tai Chi training performed as an adjunctive treatment that enhances the baroreflex control of heart rate in CHD patients.

Previous studies: Few studies have addressed the effects of Tai Chi on autonomic cardiovascular control. Väänänen, *et al*[13] studied a group of 15 elderly men with several years experience of Tai Chi exercises and 14 young male physical education students who underwent a 5 minute ECG recording before and after two series of Tai Chi movements. In both groups a significant increase was observed from resting to the postexercise condition for mean RR interval and SDNN while no significant differences were found in the LF/HF ratio. In contrast, Lu[18] showed a decrease in the LF/HF ratio at 30 and 60 minutes following Tai Chi in 20 subjects who had been practising exercises for a mean of 1.9 years. An interesting finding in this study was that when compared to 20 control subjects of similar age and cardiopulmonary function, Tai Chi practitioners showed similar heart rate but significantly higher HRV in the resting pre-exercise condition, thus suggesting an accumulated long-term effect of Tai Chi on autonomic balance. The importance of length of training in determining a sustained effect on the autonomic balance is underscored by the study of Hong, *et al*[1] who showed significantly lower resting heart rates in a group of 28 subjects with 13.2 years experience of Tai Chi exercise as compared to 30 sedentary men of similar age. Our population differed in several respects. First of all we studied CHD patients who had no previous experience in Tai Chi practice. Second, the length of Tai Chi training in our population was extended for only one year.

Although we did not observe any significant change in frequency domain HRV indices, we found a significant increase in BRS. This beneficial effect of Tai Chi training is further amplified when considering that BRS tended to decline in the control patients. Indeed, the participants in our study were older CHD patients (mean age: 68 years), a high-risk group for age-related vagal function decline.[16,19] A previous intervention study in healthy men[20] also demonstrated that regular aerobic exercise was able to modulate BRS, but not HRV. Recently, Chang[21] demonstrated that 9 months of Tai Chi training in CHD patients enhanced the change in HRV between resting and post-Tai Chi states, without an increase in resting HRV. There are similarities between the study of Chang and the current study that demonstrate more or less the same results, ie, increased reflex autonomic activity without an effect on tonic autonomic activity. However, the lack of effects on HRV in our study might also have been due to the fact that measurement of HRV by a spectral analysis technique is largely influenced by individual differences (large SDs) in a sample size of 10 patients. Further large-scale studies on HRV in Tai Chi are required to clarify this finding.

In the current study, the one-year Tai Chi training could not enhance the aerobic fitness (see Table II). Lan, *et al*[22] demonstrated that one-year Tai Chi training in patients after coronary artery bypass surgery was effective for increasing peak oxygen uptake. Differences between the results of these studies may be explained by differences in the age of study samples (68 ± 4 versus 57 ± 7 years). Consequently, the total volume of Tai Chi training at relatively high intensity may have been inadequate to improve the cardiopulmonary adaptation for our old patients.

Our findings support the results of prior research on Tai Chi and cardiovascular disease. Yeh, *et al*[23] demonstrated that a 12-week Tai Chi program for patients with chronic heart failure could significantly increase the distance walked in 6 minutes and decreased serum B-type natriuretic peptide levels. Our study provides new insight into the potential benefits of Tai Chi indicated specifically for patients with cardiovascular disease.

Potential mechanisms: The mechanism by which Tai Chi training increases the BRS remains unclear. Tai Chi consists of a sequence of semi-squat postures that can enhance the strength of the lower limbs. Iellamo, *et al*[24] indicated that moderately intense dynamic leg exercise had an adequate stimulus for decreasing the metaboreflex-induced sympathetic activation and that such exercise affects the integrated baroreflex control, suggesting that the former mechanism may be involved in the BRS responses to Tai Chi training. In addition, Tai Chi demands that participants synchronize their respiration with their slow body movements. Therefore, the occasional slow and deep breathing in patients in the Tai Chi group may shift the autonomic balance toward an increase in vagal activity and be responsible for the favorable change in BRS. Furthermore, stress reduction and other psychological aspects of the Tai Chi program may be an underlying factor mediating the training effect on the baroreflex arch.[25]

Limitations of the study: Our study has several limitations. First, we used spectral analysis for the assessment of BRS; this method is accepted but is not perfect. Second, the lack of blinding of the patients may have influenced our results. Third, there is little data concerning the independent effect of Tai Chi on autonomic nervous function. In addition, further studies are needed to explore an appropriate combination of Tai Chi with medication that affects the autonomic nervous system.

Conclusions: The one-year of Tai Chi training during cardiac rehabilitation increased BRS in patients with CHD, which is an important finding contributing to the knowledge of the effects of cardiac rehabilitation on autonomic regulation and clinical management of CHD.

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心筋梗塞後患者における集団スポーツリハビリテーションが認知機能に与える影響

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Effects of a Cardiac Sports Rehabilitation Program on Cognitive Function in Elderly Patients after Myocardial Infarction.

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Shigeru Makita**

Abstract

Purpose: Although cardiac rehabilitation is associated with numerous benefits, including improved cardiovascular health and a lower mortality rate, the current challenge is to examine whether cardiac rehabilitation can also provide cognitive benefits. This study was conducted to determine the effects of a cardiac sports rehabilitation program (CSP) on cognitive function in elderly patients. **Methods**: Twenty-one male patients after myocardial infarction (MI) (mean age: 68.8 years, mean interval time after a MI 42.1 months) completed this study. The CSP group (n=11) practiced combined Tai Chi and table tennis training once a week together with conventional exercise training for 1 year. The control group (n=10) carried out conventional exercise training only. Cognitive function was measured using a Mini-Mental State Examination (MMSE) at baseline and 1 year later. **Results**: At baseline, the MMSE score and other clinical characteristics did not differ between the two groups. After 1 year, the CSP group showed a slight increase in the MMSE score (from 26.1 +/- 1.92 to 27.3 +/- 2.81, p=0.153), while the control group showed a significant decrease (from 27.0 +/- 2.00 to 25.4 +/- 3.27, p=0.035). **Conclusions**: Supervised CSP may have implications for the prevention of cognitive decline in elderly patients after MI.

keywords: cardiac rehabilitation, cognitive function, elderly, sports, myocardial infarction

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Introduction

Although cardiac rehabilitation is associated with numerous benefits, including improved cardiovascular health and a lower mortality rate, the current challenge is to examine whether cardiac rehabilitation can also provide cognitive benefits. Longitudinal population-based studies have shown myocardial infarction (MI) [1] and cardiovascular disease [2] to be predictors of cognitive impairment among the elderly. Actually, decline in cognitive function are common problems in the elderly cardiac rehabilitation patients [3].

Exercise and leisure activities have a protective role of cognitive decline in healthy elderly [4, 5]. Especially, variety of physical activity may have positively associated with indices of cognition. Podewils and his colleagues had shown that engaging in a number of different physical activities protects against subsequent risk of dementia [6].

Taken together, additional sports programs during cardiac rehabilitation would be leads to an improved cognitive function in elderly patients with atherosclerotic vascular disease, a high-risk group for cognitive decline. To test this hypothesis, this study was conducted to determine the effects of a cardiac sports rehabilitation program (CSP) on cognitive function in elderly patients.

Methods

Participants

The study population consisted of twenty-one male patients after MI, aged 63-77 years (mean age: 69 +/-5 years), who were admitted to the Department of Rehabilitation Medicine in Saitama Medical University Hospital. Of these patients, 5 had undergone percutaneous transluminal coronary angiography (PTCA) previously and the other 16 had undergone coronary artery bypass grafting (CABG); the mean interval time after the coronary event was 42 +/- 19 months. Patients were excluded if they had stroke or systemic illness likely to affect cognition (e.g., dementia). The purpose and risk of this study were explained to each patient before written informed consent was obtained.

Design

A prospective controlled trial was designed with participants assigned either to CSR (n=11) or conventional exercise training only (control: n=10). In the CSR group, the intervention continued for 1 year. Functional outcomes were measured at baseline and after 1 year.

Intervention

After a group assignment, the CSR group met 3 hours once a week. Each session consisted of warm up, Tai Chi exercise, table tennis, and cool down. During Tai Chi exercise, the patient group was led by an instructor and they imitated the motion, adapted from classical Yang-style Tai Chi. The group practiced these programs together with conventional exercise training.

Measurements

Cognitive function was measured using a Mini-Mental State Examination (MMSE) [7]. MMSE was administered by one occupational therapist blinded to group membership.

To assess aerobic fitness, peak oxygen uptake was measured by cardiac pulmonary exercise testing (CPX) with a bicycle ergometer with an initial workload of 0 watt (W), with subsequent increments of 15W every minute until exhaustion. Oxygen consumption and carbon dioxide production were measured with a metabolic cart (Oxycon Alpha, JAEGER).

Statistical methods

All values were expressed as the mean+/-standard deviation. Differences between groups in the baseline characteristics were assessed by using the *t* test or χ^2 test as appropriate (SPSS 16.0J for Windows, SPSS inc., Chicago, USA). To compare the effects of CSR program versus the control on changes in outcome during the study period, a repeated two-way ANOVA was utilized. A value of $p<0.05$ was regarded as significant.

Results

All of the 21 enrolled patients fully completed the study. During the study period, medical treatment was maintained almost constant, and no clinical events were recorded.

The baseline characteristics of the study population are given in Table 1. No differences were observed between the CSR participants and the control patients for clinical and functional characteristics.

Table1. Baseline characteristics of patients

	CSR(n=11)	Control(n=10)	*p*
Age(yr)	70.3+/-1.4	67.2+/-1.5	NS
BMI(kg/m^2)	24.7+/-2.3	25.7+/-3.8	NS
Systolic blood pressure(mmHg)	121.9+/-20.0	122.9+/-22.2	NS
Diabetes(%)	45.4	50.0	NS
Hyperlipidemia(%)	72.7	80.0	NS
Walking steps(steps/day)	8163+/-3237	8644+/-5322	NS

Figure 1 shows the changes in MMSE score during the study period. The CSR participants showed a slight increase in MMSE score (from 26.1 to 27.3, p=0.15) while significant decrease was observed in the control patients (from 27.0 to 25.4, p=0.035). These associations persisted after adjustment for age and other covariates. The changes in peak oxygen uptake did not differ between the groups.

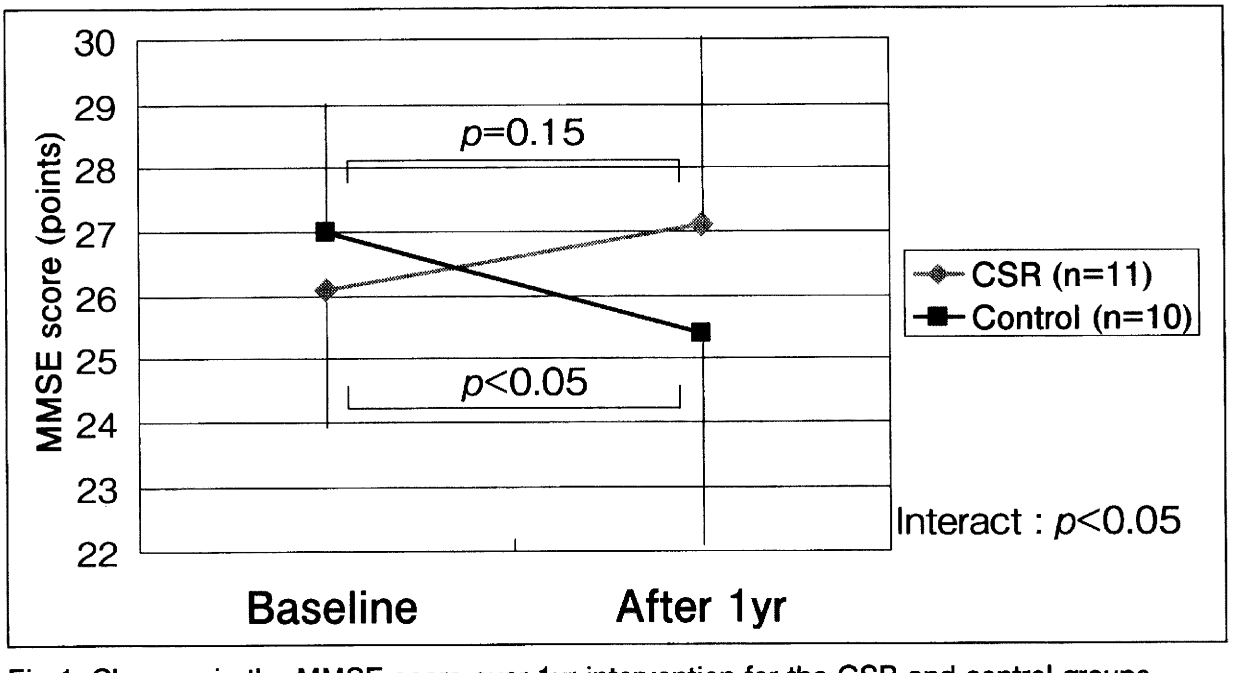

Fig 1. Changes in the MMSE score over 1yr intervention for the CSR and control groups

Discussion

We evaluated the effects of additional CSR program during cardiac rehabilitation on cognitive function in patients after MI. One-year treatment was found to result in a slight increase in the MMSE score in the CSR group while a significant decrease were observed in the control group. On the other hand, there were no significant trends seen in aerobic fitness. These observations suggest that the group sports rehabilitation program provided cognitive benefit to participants. The strength of this study is that the participants were elderly subjects with atherosclerotic vascular disease, a high-risk group for cognitive functional decline.

Variety of physical activity for the elderly is increasingly recognized as an important tool to improve cognitive function. In large prospective cohort study of community-dwelling elderly subjects, the number of different activities has a stronger association with dementia risk than dose energy expenditure [6]. In randomized pilot trail of frail community elderly subjects, those who participated in a group exercise program had a significant increase in MMSE vs. those who participated in a recreational therapy program [8]. Our study provides new insight into the potential benefits of engaging in a large number of different activities indicated specifically for patients with cardiovascular disease.

The mechanism by which CSR program remarkable prevents the cognitive decline in patients after MI remains unclear. We actually accepted that group exercise programs can promote social network among patients. Seemen et al. [9] demonstrated that persons with more developed social networks attenuate the rate of cognitive decline in older adults. Mechanisms might include association between social activity and cognitive function. Recently, the animal and human studies suggest that vigorous exercise might have effects on brain plasticity and functional brain reserves [10]. These neurogenetic mechanisms may be involved in the cognitive responses to CSR program.

In the current study, the one-year CSR program cannot enhance the aerobic fitness (Figure 2). Consequently, total volume of CSR program at relatively high intensity may have been inadequate to improve the cardiopulmonary adaptation for our old patients.

Our study had another several limitations. First, these are characteristics of studies that require intense cognitive screening. Second, we did not obtain relevant clinical data

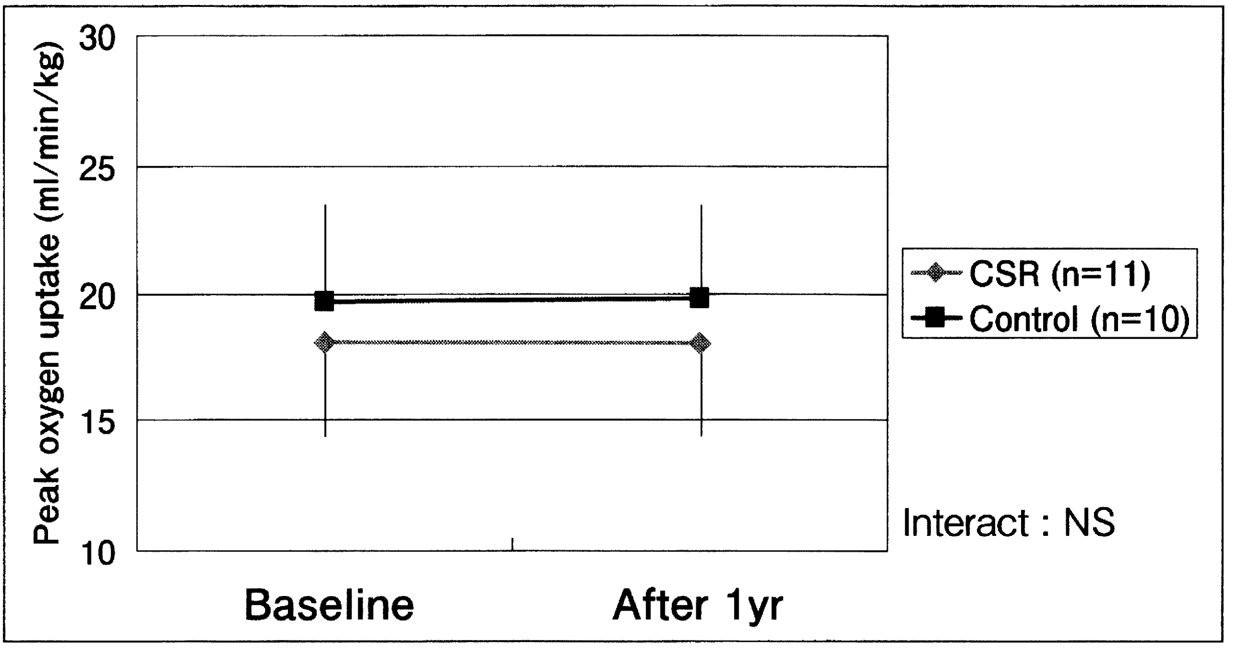

Fig 2. Changes in the peak oxygen uptake over 1yr intervention for the CSR and control groups

for the atherosclerotic risk factors, such as LDL cholesterol, HDL cholesterol, fasting serum glucose, fasting serum insulin and HbA1c. In addition, we had no objective measurement of exercise intensity in cardiac sports rehabilitation group. Further studies are needed to explore an appropriate exercise intensity of the CSR program that affects the cognitive performances.

Conclusions

Supervised CSR may have implications for the prevention of cognitive decline in elderly patients after MI. These findings may aid the designing exercise prescriptions for maintaining or improving cognitive health.

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心疾患の包括的リハビリテーションにおけるリハ科医の役割*

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はじめに

心筋梗塞患者のデコンディショニングの予防と回復から発展してきた心臓リハビリテーション（心臓リハ）であるが，今日急性期での再灌流療法の進歩や心臓手術の技術向上に伴い，その役割が疾患の再発予防や予後改善へと移行してきている．また，心臓リハの対象疾患も心筋梗塞や狭心症の虚血性心疾患はもちろんのこと，心不全，大血管疾患や末梢血管疾患等の循環器疾患全般にわたっており，幅広い対応が求められている．

アメリカ国立公衆衛生院は，心臓リハの定義を以下のように述べている．つまり，「心臓リハビリテーションサービスは，医学的な評価，処方された運動，冠危険因子の改善，教育とカウンセリングを含む包括的かつ長期的なプログラムである．これらのプログラムは，心臓病のもたらす生理学的および心理学的影響を抑制し，突然死や再梗塞のリスクを軽減し，心疾患に伴う症状をコントロールし，動脈硬化の過程を安定もしくは退縮させ，対象とされる患者に対して心理社会的，職業的状態を高めるように計画されたものである.」としている[1]．このように考えると，心臓リハは単に運動療法のみを行っていれば事足りるものではなく，食事療法や禁煙指導・生活指導を含めた包括的（comprehensive）リハを目指すべきであると考える．この目的を達成するためには，各医療専門職がチームワークで対処していかねばならない．さらに，患者のセルフコントロール支援のためには行動変容プログラムを含めた長期的な関与が求められる．しかしながら，わが国では残念ながら心臓リハが広く普及するまでには至ってない[2]．

本シンポジウムでは，リハ科医として心臓リハにどのように関わっていけばよいかを，当院の実状を述べながら解説したい．

当院における心臓リハ概要

埼玉医科大学国際医療センターはベッド数600床の急性期病院である．救急救命センター（脳卒中センターを含める），心臓病センター，包括的がんセンターの3つのセンターからなり，埼玉県全域を診療圏として，がん，心臓病に対応する高度専門特殊医療に特化し，かつ高度の救命救急医療を提供することを目的として2007年4月に開院した．したがって，対象疾患は脳卒中，心臓病，多発外傷等の救急疾患，がんである．心臓リハ科は2008年4月1日に独立した診療科として認められ，リハ部門は，当科と運動・呼吸器リハ科に分かれて診療を担当するようになった．当科は運動・呼吸器リハ科が担当する脳卒中と中枢神経系がん以外の患者のリハ診療を行っている．

心疾患は文字通り心臓リハ科の主要な対象疾患である．心臓リハ科担当医（心臓リハ科医）2名，理学療法士5名（専従2名）と専従看護師ならびに専従臨床検査技師が1名ずつ配置されている．作業療法士は他疾患のリハと重複している．管理栄養士は栄養部に所属しており定期的に行われる心臓リハカンファレンスに参加している．

急性期心臓リハの概要（**図1**）であるが，虚血性心疾患発症または心臓手術後に主治医（心臓内科医もしくは心臓外科医）から心臓リハの依頼が出されて，心臓リハ科医がベッドサイドで診察してリハ処方を療法士に指示する．循環動態が安定していれば，通常は急性心筋梗塞発症後・心臓手術の翌日に依頼が出る．したがって，早ければ心臓リハ開始は発症後もしくは術後翌日からとなる．その後リハプログラムにしたがって，理学療法士が早期離床に向けてベッドサイドでのリハを開始する．廃用や運動障害が顕著な患者について

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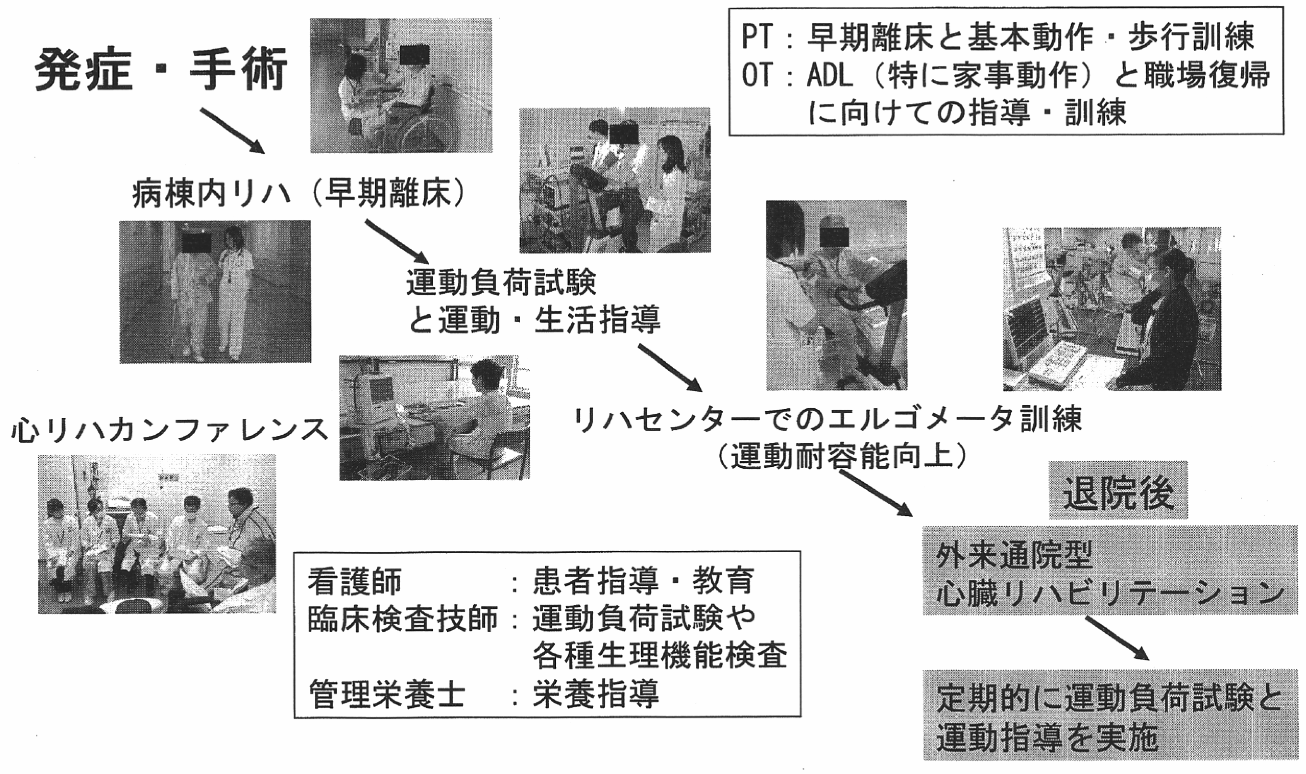

図 1　国際医療センターにおける心臓リハの流れ
PT：理学療法士，OT：作業療法士

は，必要性を判断して作業療法士へ指示を出すこともある．病棟内の自立歩行が可能となり，ジムまでの移動が問題なく実施できるようになれば，心肺運動負荷試験（CPX）を行い AT（anaerobic threshold：嫌気性代謝閾値）レベルでの自転車エルゴメータによる有酸素トレーニングを退院まで継続する．有酸素トレーニングは心電図モニター監視下で一日 2 回（1 回 30 分）行い，その間に看護師が患者の情報収集と生活指導と教育を合わせて実施する．退院後に外来通院が可能な患者は，回復期の外来通院型心臓リハを行う．外来リハが終了した患者は，その後 3～6 カ月毎に通院して CPX による運動耐容能評価と運動指導を心臓リハ科医が行い主治医であるかかりつけ医に報告している．

1. 心臓内科領域での心臓リハ

急性心筋梗塞後の心臓リハについては，当科のクリニカルパスにしたがってリスク管理をしながら進めている[3]．開設年度に当たる 2007 年度の心臓リハ処方件数は 198 件であったが，翌 2008 年度は 282 件と増加している（**図 2**）．疾患別にみると急性心筋梗塞が増加しているが，心不全患者の増加が前年比 57％と目立っている．また大動脈解離等の大血管疾患のリハの増加も特徴となっている．狭心症が少ないのは，PCI（percutaneous coronary intervention）後に心臓リハを行わずに短期間で退院することが考えられ，これは全国的にみて同様の傾向である．再発予防や冠危険因子是正といった心臓リハの目的から考えると，狭心症患者にこそ心臓リハが必要であると考えられ今後の課題といえる．

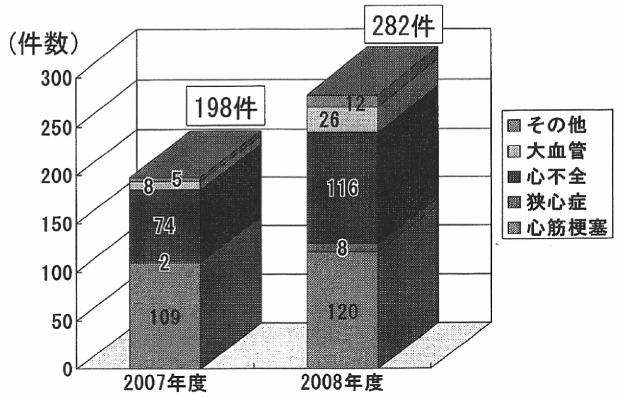

図 2　心臓内科における心臓リハ処方件数