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ORIGINAL ARTICLE
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Pulmonary Endarterectomy and Balloon Pulmonary Angioplasty for Chronic Thromboembolic Pulmonary Hypertension

— Similar Effects on Health-Related Quality of Life —

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Background: While hemodynamics and exercise capacity in patients with chronic thromboembolic pulmonary hypertension (CTEPH) can be improved by invasive therapy such as pulmonary endarterectomy (PEA) and balloon pulmonary angioplasty (BPA), there has been little data on the health-related quality of life (HRQOL) in such patients.

Methods and Results: This single-center and observational study compared the impact of invasive therapy on HRQOL. We utilized the Medical Outcome Study 36-Item Short Health Survey (SF-36) to measure HRQOL and compared HRQOL changes after PEA and BPA. A total of 48 patients were diagnosed with CTEPH. Of these, 39 patients completed questionnaires before and after invasive therapy. The PEA group (n=15) and the BPA group (n=24) had similar improvements in clinical parameters. With regard to HRQOL score, both groups had fairly low scores in physical functioning (PF), role physical (RP), general health (GH), social functioning (SF), role emotional (RE), and physical component summary (PCS) at baseline. PF, GH, vitality (VT), mental health (MH), and PCS had significant improvements in the PEA group while PCS and all subscales except for bodily pain (BP) had significant improvements in the BPA group. Furthermore, changes between baseline and follow-up were not significantly different between the 2 groups.

Conclusions: BPA for patients who are ineligible for PEA can recover HRQOL to a similar level to that achieved by PEA.

Key Words: Balloon pulmonary angioplasty; Chronic thromboembolic pulmonary hypertension; Health-related quality of life; Pulmonary endarterectomy; SF-36

Chronic thromboembolic pulmonary hypertension (CTEPH) is a rare disease characterized by fibrothrombotic obstructions of the pulmonary arteries (PA), resulting in increased pulmonary vascular resistance (PVR), pulmonary vascular remodeling and eventually leading to right ventricular failure.[1] The primary therapy for CTEPH has been pulmonary endarterectomy (PEA),[2] which contributes to better hemodynamics, oxygenation, exercise capacity, and prognosis.[3,4] CTEPH prognosis had been poor until the development of PEA.[5,6] Subsequently, balloon pulmonary angioplasty (BPA) was introduced, which had similarly beneficial effects on hemodynamics, exercise tolerance, and prognosis in patients with inoperable or surgically inaccessible disease.[7–12] In spite of the progress in therapeutic options, some patients who have undergone PEA or BPA still had residual symptoms.[13,14]

Health-related quality of life (HRQOL) measurement is a subjective outcome that represents disease impact on a person's function and wellbeing, and can be altered by disease treatment.[15,16] Beyond objective outcomes such as

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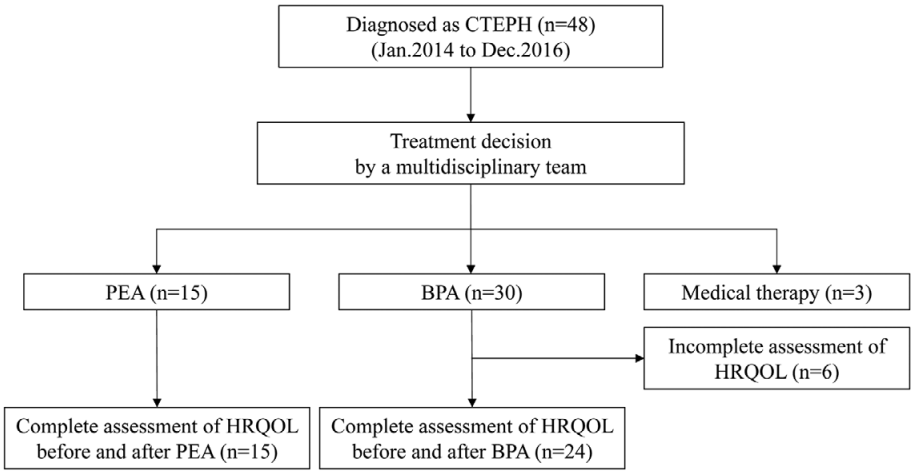

Figure 1. Workflow of the observational study. BPA, balloon pulmonary angioplasty; CTEPH, chronic thromboembolic pulmonary hypertension; HRQOL, health-related quality of life; PEA, pulmonary endarterectomy.

hemodynamics and exercise tolerance, HRQOL assessment is also important because it is a subjective outcome that reflects the patient's perspective. Mathai et al reported that HRQOL in patients with pulmonary arterial hypertension (PAH) was associated with World Health Organization functional class (WHO-FC), 6-min walk distance (6MWD), and even transplant-free survival time.[17] For CTEPH, there have been several publications on HRQOL. Urushibara et al reported that longer 6MWD and lower PVR were associated with higher HRQOL score in treatment-naïve patients.[18] Moreover, in the same study, a surgically treated group had better improvements in HRQOL than a medically treated group.[18] Furthermore, Darocha et al reported that HRQOL was improved by BPA.[19] We previously identified early introduction of invasive therapies as a factor affecting final HRQOL.[20] In spite of these previous studies, there has been no report on the non-inferiority of BPA to PEA in terms of HRQOL improvement. We therefore aimed to clarify the effects of BPA on these patients compared with those who underwent PEA, given that BPA is a fairly new therapy that is generally considered in patients who are not eligible for PEA.[21]

Based on previous reports, we hypothesized that even patients ineligible for PEA could attain similar HRQOL improvement with BPA. The aim of this study was therefore to compare the impacts of PEA and BPA on HRQOL.

Methods

This study was approved by the Ethics Committee of Kobe University Graduate School of Medicine (approval no. 160171). Written informed consent was given by all patients before catheterization.

Subjects

Between January 2014 and December 2016, a total of 48 patients were diagnosed with CTEPH at Kobe University Hospital. The diagnosis of CTEPH was established on medical history, physical examination, electrocardiogram, chest radiography, echocardiography, computed tomography (CT), lung ventilation-perfusion scintigraphy, right heart catheterization (RHC), and pulmonary angiography (PAG) in accordance with clinical guidelines.[21] Treatment approaches were assessed by a multidisciplinary team and patients were re-evaluated after treatment. Patients who could complete questionnaires both before and after invasive therapy were included in this study, while patients who could not complete questionnaires or were treated with a medical therapy were excluded from this study (**Figure 1**).

Eligibility for Surgery

Eligibility for surgery was discussed by a multidisciplinary team that consisted of cardiologists, interventional cardiologists, and cardiac surgeons, as detailed in our previous report.[11] Surgical eligibility was based on preoperative WHO-FC II–IV and surgical accessibility of thrombi identified on PAG. Main lesions in the pulmonary trunk, lobar PA, or segmental PA were defined as the proximal type, while main lesions in the distal segment to subsegmental PA were defined as the distal type. Patients with the proximal type were considered as candidates for PEA if they had no comorbidities that endangered perioperative safety. BPA was considered if PEA was not indicated. Patients provided written informed consent to undergo PEA or BPA.

PEA

PEA was carried out as described in our previous report.[11] Briefly, bilateral PEA was performed through a median sternotomy and was conducted with intermittent circulatory arrest for a period limited to 20 min, while the core temperature was maintained at 16°C. Perioperative medical treatment such as catecholamines, nitric oxide, phosphodiesterase III inhibitors, epoprostenol, or diuretics was given until recovery.

BPA

BPA was carried out as described in our previous reports.[11,22] Briefly, the femoral vein was selected using a 9-Fr short sheath, and a 6-Fr guiding sheath was inserted into the PA

Table 1. Baseline Subject Characteristics

Variables	PEA (n=15)	BPA (n=24)	P-value
Age (years)	61.7±3.3	64.1±2.6	0.449
Time from baseline to follow-up (months)	6.8±1.0	13.3±1.9	0.022
Time from symptom onset to invasive therapy (months)	55.3±13.5	32.8±6.7	0.146
Time from last invasive therapy to follow-up (months)	4.4±0.7	7.9±1.5	0.097
No. BPA sessions	NA	3.25±0.3	NA
Female	10 (67)	20 (83)	0.208*
Central disease	15 (100)	5 (21)	<0.001*
WHO-FC (I/II/III/IV)	0/2/10/3	0/3/21/0	0.399
Treatment			
PAH-specific monotherapy	3 (20)	4 (17)	0.556*
PAH-specific combination therapy	2 (13)	5 (21)	0.444*
Warfarin	15 (100)	24 (100)	NA
HOT	6 (40)	11 (46)	0.721*
Right heart catheterization			
mPAP (mmHg)	42.7±1.6	33.8±2.2	0.004
mRAP (mmHg)	5.2±0.7	4.8±0.6	0.679
PCWP (mmHg)	9.1±1.1	8.0±0.7	0.539
CI (L/min/m^2)	1.82±0.10	2.04±0.13	0.432
PVR (Wood units)	12.2±1.2	9.0±1.0	0.015
SaO_2 (%)	90.1±1.2	90.3±0.9	0.915
SvO_2 (%)	59.2±1.6	63.3±1.4	0.080
Exercise capacity			
6MWD (m)	281±40	352±20	0.038
Peak $\dot{V}O_2$ (mL/min/kg)	12.3±1.2	14.1±1.4	0.525
$\dot{V}E/\dot{V}CO_2$ slope	47.3±4.6	43.0±3.7	0.365
Pulmonary function			
%VC	86.0±4.8	90.7±3.6	0.415
FEV_1/FVC	0.745±0.022	0.750±0.017	0.253
$\%DL_{CO}$	60.6±3.1	60.7±2.6	0.853

Data given as mean±SE, n, or n (%). *Mann-Whitney U-test (chi-squared test). 6MWD, 6-min walk distance; $\%DL_{CO}$, diffusion capacity of carbon monoxide as the percent of predicted; %VC, vital capacity as the percent of predicted; BPA, balloon pulmonary angioplasty; CI, cardiac index; FEV_1, forced expiratory volume in 1 s; FVC, forced vital capacity; HOT, home oxygen therapy; NA, not available; mPAP, mean pulmonary arterial pressure; mRAP, mean right atrial pressure; PAH, pulmonary arterial hypertension; PaO_2, partial pressure of oxygen; PCWP, pulmonary capillary wedge pressure; PEA, pulmonary endarterectomy; PVR, pulmonary vascular resistance; SaO_2, arterial oxygen saturation; SvO_2, mixed venous oxygen saturation; $\dot{V}E/\dot{V}CO_2$, minute ventilation/carbon dioxide production; $\dot{V}O_2$, oxygen uptake; WHO-FC, World Health Organization functional class.

through the femoral vein. A 6-Fr guiding catheter was engaged into the targeting sectional branches and a 0.014-inch guide wire was crossed through the lesion. After assessment on intravascular ultrasound, the lesion was dilated using 2.0–7.0-mm monorail balloons. At each hospitalization, 2 sessions of BPA were performed, and RHC was performed once after the last session to assess efficacy.

HRQOL Assessment

We utilized the Medical Outcome Study 36-Item Short-Form Health Survey (SF-36) version 2, which is a comprehensive measurement of HRQOL.[23] Eight subscales are obtained from the questionnaire: physical functioning (PF), role physical (RP), bodily pain (BP), general health (GH), vitality (VT), social functioning (SF), role emotional (RE), and mental health (MH). Two summary scores, physical component summary (PCS) and mental component summary (MCS), are calculated from the 8 subscales. All the subscales (raw score) are scaled to have a national average of 50 and a standard deviation of 10 (normalized score). The patients were requested to complete the SF-36 version 2 during hospitalization for baseline RHC and for follow-up RHC after PEA or BPA.

Clinical Parameters

WHO-FC, hemodynamics, oxygenation, exercise capacity, pulmonary function, and brain natriuretic peptide (BNP) were evaluated at diagnosis and after completion of PEA or BPA. Hemodynamics parameters were obtained from RHC, including right atrium pressure, mean pulmonary arterial pressure (mPAP), pulmonary capillary wedge pressure (PCWP), oxygen saturation (SaO_2), partial pressure of oxygen (PaO_2), and mixed venous oxygen saturation (SvO_2). Cardiac output (CO) and cardiac index (CI) were calculated using the Fick method. PVR was calculated using the following formula: (mPAP−PCWP)×80/CO. 6MWD and cardiopulmonary exercise test (CPET) were evaluated for exercise tolerance.[24] Pulmonary function was evaluated by measuring vital capacity as a percentage of predicted vital capacity (%VC), the ratio of forced expiratory

Table 2. Parameter Change From Baseline to Follow-up

Variables	PEA (n=15)				BPA (n=24)			
	n	Baseline	Follow-up	P-value†	n	Baseline	Follow-up	P-value†
WHO-FC (I/II/III/IV)	15	0/2/10/3	2/2/11/0	0.020	24	0/3/21/0	4/5/15/0	0.015
mPAP (mmHg)	15	42.7±1.6	24.6±1.7	0.001	24	33.8±2.2	21.9±1.7	<0.001
mRAP (mmHg)	15	5.2±0.7	5.1±0.7	0.925	24	4.8±0.6	2.9±0.5	0.024
PCWP (mmHg)	15	9.1±1.1	9.3±1.1	0.826	24	8.0±0.7	6.9±0.6	0.384
CI (L/min/m^2)	15	1.82±0.10	2.34±0.16	0.003	24	2.04±0.13	2.35±0.10	0.014
PVR (Wood units)	15	12.2±1.2	4.6±0.7	0.001	24	9.0±1.0	4.1±0.3	<0.001
SaO_2 (%)	15	90.1±1.2	94.2±0.6	0.006	22	90.3±0.9	94.4±0.9	0.002
SvO_2 (%)	15	59.2±1.6	64.3±1.5	0.029	22	63.3±1.4	69.6±1.0	0.001
BNP (pg/mL)	15	416±77	161±40	0.001	23	200±67	43±14	0.008
6MWD (m)	15	281±40	372±33	0.031	23	352±20	386±21	0.024
Peak $\dot{V}O_2$ (mL/min/kg)	8	12.3±1.2	14.2±1.1	0.362	14	14.1±1.4	17.5±1.3	0.009
$\dot{V}E/\dot{V}CO_2$ slope	8	47.3±4.6	39.4±2.5	0.161	14	43.0±3.7	31.1±1.7	0.003

Data given as mean±SE or n. †Paired Wilcoxon signed-rank test. BNP, brain natriuretic peptide. Other abbreviations as in Table 1.

Table 3. Effect of Invasive Therapy on HRQOL

Variables	PEA (n=15)			BPA (n=24)			Change between baseline and follow-up		
	Baseline	Follow-up	P-value†	Baseline	Follow-up	P-value†	PEA	BPA	P-value‡
PF	12.4±5.2	31.7±4.3	0.001	25.4±2.9	38.6±2.7	0.001	+19.2±4.0	+13.2±3.3	0.191
	(34.3±7.4)	(61.7±6.1)		(52.7±4.1)	(71.5±3.9)		(+27.3±5.6)	(+18.8±4.7)	
RP	27.6±4.9	38.7±3.8	0.124	28.3±3.3	38.5±2.7	0.002	+11.1±6.7	+10.2±3.3	0.638
	(47.5±8.9)	(67.9±6.9)		(48.7±6.0)	(67.4±5.0)		(+20.4±12.2)	(+18.8±6.1)	
BP	48.9±3.9	49.2±2.4	0.916	47.6±2.5	46.1±2.3	0.647	+0.3±3.4	−1.5±2.7	0.618
	(71.8±8.8)	(72.4±5.4)		(68.7±5.7)	(65.3±5.1)		(+0.6±7.6)	(−3.4±6.0)	
GH	37.7±2.7	47.8±2.2	0.001	36.9±2.1	44.0±2.0	0.005	+10.1±1.4	+7.2±1.9	0.212
	(41.3±5.1)	(59.9±4.1)		(39.8±3.9)	(53.0±3.7)		(+18.7±2.6)	(+13.3±3.6)	
VT	42.9±4.0	52.1±2.2	0.044	43.6±1.9	48.7±1.9	0.007	+9.2±3.7	+5.1±1.5	0.449
	(47.5±8.2)	(66.3±4.4)		(49.0±4.0)	(59.4±3.8)		(+18.7±7.4)	(+10.4±3.1)	
SF	36.1±4.2	45.7±3.0	0.113	35.4±2.9	42.6±2.8	0.044	+9.6±5.0	+7.1±3.3	1.000
	(60.0±8.0)	(78.3±5.7)		(58.9±5.6)	(72.4±5.4)		(+18.3±9.6)	(+13.5±6.3)	
RE	39.3±4.2	43.2±4.1	0.327	34.4±3.6	42.2±3.4	0.007	+4.0±5.1	+7.8±2.9	0.352
	(66.1±8.3)	(73.9±8.0)		(56.6±7.0)	(71.9±6.7)		(+7.8±10.0)	(+15.3±5.6)	
MH	47.7±3.2	52.8±2.4	0.049	44.9±2.1	51.4±1.7	0.002	+5.1±2.4	+6.5±1.6	0.786
	(67.3±6.0)	(77.0±4.4)		(62.1±3.9)	(74.4±3.2)		(+9.7±4.5)	(+12.3±3.1)	
PCS	19.6±4.7	32.2±4.1	0.023	24.3±3.0	35.1±2.9	0.002	+12.6±4.7	+10.8±2.9	0.786
MCS	53.2±2.7	57.5±2.1	0.100	49.6±1.7	52.4±1.3	0.189	+4.3±2.1	+2.8±1.8	0.743

Data given as mean±SE. HRQOL scores are presented as normalized scores and raw scores are given in parentheses. †Wilcoxon signed-rank test or ‡Mann-Whitney U-test. BP, bodily pain; GH, general health; HRQOL, health-related quality of life; MCS, mental component summary; MH, mental health; PCS, physical component summary; PF, physical functioning; RE, role emotional; RP, role physical; SF, social functioning; VT, vitality.

volume in 1 s to forced vital capacity (FEV_1/FVC), and diffusion capacity of carbon monoxide as a percentage of predicted diffusion capacity (%DL_{CO}).

Statistical Analysis

Continuous variables are expressed as mean±SE. We adopted non-parametric statistics due to the small sample size. Differences between the BPA and PEA groups were determined using the Mann-Whitney U-test. Change after invasive therapy was determined using the Wilcoxon signed-rank test. Differences in frequencies were analyzed using the chi-squared test. $P<0.05$ was considered statistically significant. Spearman correlation coefficient was used to measure the linear relationship between clinical parameters and HRQOL score. Statistical analysis was performed using SPSS statistics 23.0 (SPSS Japan, Tokyo, Japan).

Results

Of the 48 patients, 15 patients underwent PEA, 30 patients underwent BPA, and 3 patients underwent medical therapy. Of the 45 patients treated with PEA or BPA, 3 patients treated with BPA could not complete the HRQOL questionnaire at diagnosis and 3 patients treated with BPA could not complete the follow-up examinations. Therefore, we analyzed the data for 15 PEA-treated patients (PEA group) and 24 BPA-treated patients (BPA group) in this study (**Figure 1**).

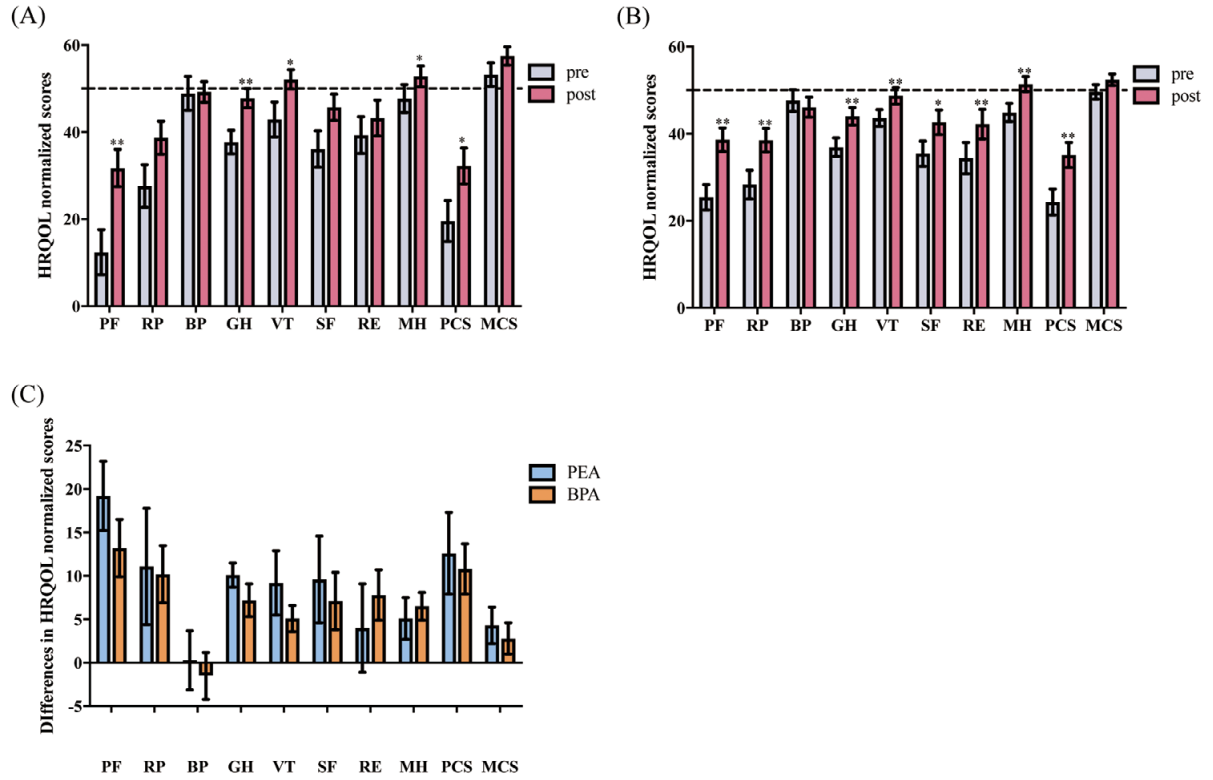

Figure 2. Effects of (**A**) pulmonary endarterectomy (PEA) and (**B**) balloon pulmonary angioplasty (BPA) on health-related quality of life (HRQOL). (**C**) Differences in HRQOL scores after the 2 therapies. Changes after invasive therapy were determined using the Wilcoxon signed-rank test. Differences between the BPA and PEA groups were determined using the Mann-Whitney U-test. *P<0.05; **P<0.01. BP, bodily pain; GH, general health; MCS, mental component summary; MH, mental health; PCS, physical component summary; PF, physical functioning; RE, role emotional; RP, role physical; SF, social functioning; VT, vitality.

Baseline Characteristics

The baseline characteristics are summarized in **Table 1**. Of 5 BPA patients who were categorized as the central group, 2 patients were not eligible for PEA because of advanced age (>75 years old) and 3 patients rejected PEA. The 2 groups had similar age, gender ratio, and therapeutic regimen including pulmonary vasodilators and home oxygen therapy. The patients who underwent PEA had significantly higher mPAP and PVR and significantly lower exercise tolerance than the patients who underwent BPA.

Effects of PEA and BPA on Clinical Parameters

Table 2 lists the effects of PEA and BPA on clinical parameters. WHO-FC, hemodynamics (mPAP, PVR, CI), SaO_2, SvO_2, 6MWD, and BNP had significant improvements following both invasive therapies. While the BPA group had significant improvements in CPET parameters (peak $\dot{V}O_2$, $\dot{V}E/\dot{V}CO_2$ slope), the PEA group showed a tendency toward improvement in those parameters that did not reach significance. These results were in accordance with previous reports,[3,8–11] showing that the present patients were treated appropriately.

Effects of PEA and BPA on HRQOL

Table 3, **Figure 2** present the effects of PEA and BPA on HRQOL. Both groups had low HRQOL at baseline. In particular, 5 of 8 subscales (PF, RP, GH, SF, and RE) and PCS had low scores <1 SD below the mean. The other subscales (BP, VT, and MH) had low scores >1 SD below the mean while MCS was normal. PEA significantly improved PF, GH, VT, and MH with a tendency toward improvement in RP, SF, and RE. In contrast, BPA significantly improved all the aforementioned parameters. BP did not improve in either group. Both PEA and BPA contributed to significantly improved PCS. We compared the changes in HRQOL scores affected by the 2 invasive therapies to determine if these 2 invasive therapies had different effects on HRQOL improvement. There were no significant differences in HRQOL score between the 2 groups (**Table 3**; **Figure 2C**). Although PEA and BPA contributed to better HRQOL scores, almost all of them in both groups were still low compared with the national average. In particular, PF, RP, and PCS were still <40 even after the invasive therapies.

HRQOL Score and Clinical Parameters

We analyzed the correlation between HRQOL score and clinical parameters before and after invasive therapies in order to investigate whether the association between HRQOL score and clinical parameters was altered by invasive therapies. Before invasive therapies, 3 of 8 subscales and PCS had significant correlations with clinical parameters: PF with BNP (r=−0.34) and 6MWD (r=0.44), RP with SaO_2 (r=0.43), SF with mPAP (r=−0.40), and PCS

with 6MWD (r=0.33; **Supplementary Table 1**). After invasive therapies, 4 of 8 subscales and PCS had significant correlations with clinical parameters: PF with time from symptom onset to invasive therapy (r=−0.42) and 6MWD (r=0.43); RP with age (r=−0.33), PVR (r=−0.32), SvO_2 (r=0.45), and 6MWD (r=0.39); SF with PVR (r=−0.40); RE with SvO_2 (r=0.42), and 6MWD (r=0.40); and PCS with time from symptom onset to invasive therapy (r=−0.33), PVR (r=−0.33), SvO_2 (r=0.50), and 6MWD (r=0.49; **Supplementary Table 2**).

Discussion

The present study evaluated HRQOL scores in patients to whom therapeutic approaches were assigned in accordance with current guidelines and by consensus.

This study has shown that both treatments could significantly improve hemodynamics, oxygenation, 6MWD, and BNP. The PEA group, however, did not show significant improvement in CPET parameters (**Table 2**). We believe that there are 2 reasons for this. First, the sample size in the PEA group was small. Second, the time from invasive therapy to follow-up was shorter in the PEA group compared with the BPA group (4.4 months vs. 7.9 months). This short follow-up period might have resulted in the apparent insufficient improvements in parameters from CPET, because these parameters in PEA-treated patients had been shown to improve with time.[25]

For HRQOL scores, PF, GH, VT, and MH were significantly improved by both PEA and BPA, leading to significantly better PCS in both groups. Even though significant improvements in RP, SF, and RE were seen only in the BPA group, the parameters showed a similar tendency toward improvement in both groups. We think that this non-significance was due to small sample size in the PEA group. Furthermore, the improvement in HRQOL score by invasive therapies was not significantly different between the PEA group and the BPA group. Patients who have undergone PEA or BPA have been shown to have better hemodynamics, exercise tolerance, and longitudinal clinical prognosis.[3,4,8–12] There have been only a few studies, however, in which HRQOL score was utilized as a clinical outcome. Although PEA and BPA contribute to better HRQOL in patients with CTEPH,[18,19] the question of whether patients who have undergone BPA could have improved HRQOL to the same extent as that in PEA has not been addressed. In this study, we show for the first time that HRQOL improvement in BPA-treated patients was not inferior to that of PEA-treated patients, suggesting that patients ineligible for PEA can receive HRQOL improvement by BPA similar to that of patients with operable disease.

Based on the aforementioned findings, patients with CTEPH can improve HRQOL in addition to hemodynamics and exercise tolerance by invasive therapy. But even after attaining mPAP ≤25 mmHg, almost all of the HRQOL scores in both groups were still low compared with the national average. In particular, PF, RP, and PCS were still <1 SD below the mean. This indicates that even after PEA or BPA, patients still have impaired HRQOL. We believe that 2 factors can contribute to better HRQOL in patients with CTEPH. First, in our previous report, we showed that early introduction of PEA or BPA could contribute to better HRQOL after invasive therapy in CTEPH.[20] From the present results, early diagnosis and introduction of invasive therapy are likely essential for better HRQOL after invasive therapy. Second, we might reconsider the goal of invasive therapy in CTEPH. In our previous reports, both extensive revascularization by BPA and sequential hybrid therapy with PEA and additional BPA contributed to amelioration of symptoms and exercise capacity in patients with CTEPH.[13,14] It can therefore be hypothesized that additional BPA in addition to PEA or standard BPA might lead to better HRQOL. Further investigation is required to elucidate whether additional BPA can contribute to better HRQOL in patients previously treated with PEA or BPA.

MCS and BP did not show significant improvement in either the PEA or BPA groups. For MCS, previous studies have shown a significant improvement by PEA[18] and BPA.[19] MCS improvement in the present study, however, was not significant. MCS might have been preserved from baseline or the small improvement might have been due to the small sample size. In patients with chronic heart failure, BP was not lower than the national average.[26] BP score in the present study was similarly in accordance with this result. Furthermore, not many patients with CTEPH have a history of chest pain in clinical practice. Therefore, we do not believe that BP was affected by CTEPH, and was appropriate for the evaluation of CTEPH.

There are several studies in which 6MWD and PVR were associated with HRQOL scores in patients with PAH or CTEPH.[17,18] In this study, we analyzed the correlation between HRQOL scores and clinical parameters before and after invasive therapy in order to investigate whether association between HRQOL score and clinical parameters was altered by invasive therapy. Before invasive therapy, BNP, mPAP, SaO_2, and 6MWD had correlations with HRQOL scores. After invasive therapy, age, time from symptom onset to invasive therapy, PVR, SvO_2, and 6MWD had correlations with HRQOL scores. This indicates that 6MWD would be a useful marker reflecting HRQOL in patients with CTEPH both before and after therapy. This would also suggest that patients with low 6MWD have low HRQOL.

Study Limitations

This study had several limitations. First, the present study was a retrospective, single-center, and small-sample study. Larger prospective studies are needed to further investigate HRQOL in CTEPH patients. Second, baseline characteristics between the PEA group and the BPA group, such as mPAP, PVR, and 6MWD, were significantly different. Although HRQOL improvement between the 2 groups was similar, these differences might reflect selection bias. Third, there may be gender-related differences. In this study, a higher percentage of women were included. We were unable, however, to analyze gender-related differences because of the small sample size. A fourth limitation is the measurement of HRQOL itself. SF-36 is not a disease-specific HRQOL measurement, but a comprehensive measurement of HRQOL. We adopted this measurement because its scores can be compared with the healthy population.[23,27] It may, however, be less sensitive to changes in HRQOL in CTEPH patients.[16] Therefore, it might be better to utilize a disease-specific measurement to assess the effect of invasive therapy.

Conclusions

Both BPA and PEA contribute to better HRQOL in

patients with CTEPH. This suggests that patients ineligible for PEA can achieve equivalent clinical outcomes to those patients eligible for PEA. Almost all CTEPH patients can achieve improved HRQOL as well as hemodynamics and exercise tolerance by PEA or BPA.

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Supplementary Files

Please find supplementary file(s);
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