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Original article

A Comparison of 30-Day Survival Rate Between Hemoperfusion and Non Hemoperfusion Group in Severe COVID-19 Pneumonia Patients

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Abstract The cytokine storm is a severe complication of SARS-CoV-2 infection. Hemoperfusion (HP) is an extracorporeal blood purification that can remove cytokines effectively. However, little is known about the efficacy of HP on severe COVID-19 infection. We aimed to study the efficacy of HP in severe COVID-19 pneumonia. This study was a retrospective study in severe COVID-19 pneumonia with CRP ≥50 mg/L. All participants received standard treatment and were admitted to ICU at Chaophrayayommarat (Pan Sukhum) Suphanburi Hospital from April, 2021 to October, 2021. The study group defined as patients who were treated with HP ≥3 sessions (the HP group) and the control group defined as patients were treated with the standard treatment alone (the non-HP group). The primary outcome was 30-day survival rate. One hundred thirty-eight patients were enrolled in this study, 69 patients in the HP group and 69 patients in the non-HP group. The 30-day survival rate in the HP group was 58% (95%CI 45-70%) and in the non-HP group was 42 % (95%CI 30-55%), p = 0.061. On day 3, the reduction of CRP level was significantly higher in the HP group than the non-HP group, p=0.032. For non-intubated patients before treatment, the rate of intubation in the HP group was 34.5% and in the non-HP group was 52.6%, p=0.05. In the HP group, the non-intubated patients (n = 58) before HP had a survival rate of 65.5% and the intubated patients (n = 11) before hemoperfusion had a survival rate of 18.2%, p=0.005. In a multivariable model, the significant variables independently associated with survival rate are age (adjusted odds ratio 0.94 (95%CI 0.91, 0.98; p=0.003)) and ROX index level (adjusted odds ratio 2.20 (95%CI1.55, 3.12; p<0.001)). In conclusion, the 30-day survival rate in severe COVID-19 pneumonia patients who received standard treatment and HP was higher than in standard treatment alone and interestingly, the rate of intubation was also lower in the HP group. Well design randomized control trial is still warranted.

***Keywords*: severe COVID-19 pneumonia; cytokine storm; hemoperfusion**

Introduction

The first case of Coronavirus disease 2019 was discovered in December 2019 in China[1] and pronounced as a pandemic by World Health Organization on 11 March 2020.[2] If the patients developed acute respiratory failure, the mortality rate increased up to 61.5%.[3] Hyperinflammatory state caused by uncontrolled overproduction of pro-inflammatory cytokines (esp. interleukin IL-1β, IL-6) can result in severe COVID-19 infection and multiple organ failure. Therefore, immunomodulatory agents such as corticosteroids and tocilizumab might mitigate this hyperinflammatory response and provide additional improvement in clinical outcomes.[4-10] Recently introduced, cytokine removal by hemoperfusion (HP) technique, which removes cytokines from the blood when passes through a specific cartridge containing adsorbent particles by a simple circuit, could be an option to mitigate those pro-inflammatory cytokines.[11,12] Many experimental researches about HP were the study protocols, criteria selection of patients, other extracorporeal blood purification techniques such as continuous renal replacement therapy (CRRT), HP cartridges, timing, duration, and level of severity of infection have resulted in the different outcomes.[13-24] Soleimani A et al. had performed HP in 24 patients in addition to treatment with conventional antiviral therapies. The HP resulted in a significant increase in the SpO2 levels and a significant decrease in the CRP of patients compared to the conventional treatment, but does not affect on mortality.[13] Teresa R et al. treated 5 patients in the early course of COVID-19 pneumonia and received 2 consecutive sessions of HP using a CytoSorb cartridge suggesting a potentially improved respiratory function and lower mortality than 4 control patients. The limitation of this study was the sample size and retrospective designed.[14] Ilad AD et al. enrolled 128 critically ill COVID-19 patients; 73 patients were allotted to the matched group and 55 patients received HP. They found a significant reduction in mortality rate and improvement of SpO_2 and pCO_2 in the HP group.[15] Karjbundid S et al. conducted a prospective cohort study with 29 severe COVID-19 patients. They compared the HP group (defined as 15 patients who were treated with HP therapy at least 3 sessions in combination with standard therapy) and the control group (defined as 14 patients who received standard treatment alone or received less than 3 sessions of HP therapy). The results of the addition of early HA-330 hemoperfusion to standard therapy improved the severity of organ failure and might reduce the mortality rate. However, the results were affected by the baseline confounders and limited sample size.[24] Although early HP studied seemed to show beneficial outcomes[24,25] but currently no definite recommendation on indication, timing, and protocol to start the treatment.

We aimed to compare the 30-day survival rate between the hemoperfusion and the non-hemoperfusion groups in severe COVID-19 pneumonia patients who had high CRP as the primary outcome. The secondary outcome was the potential factors associated with the survival rate at 30-day.

Methods

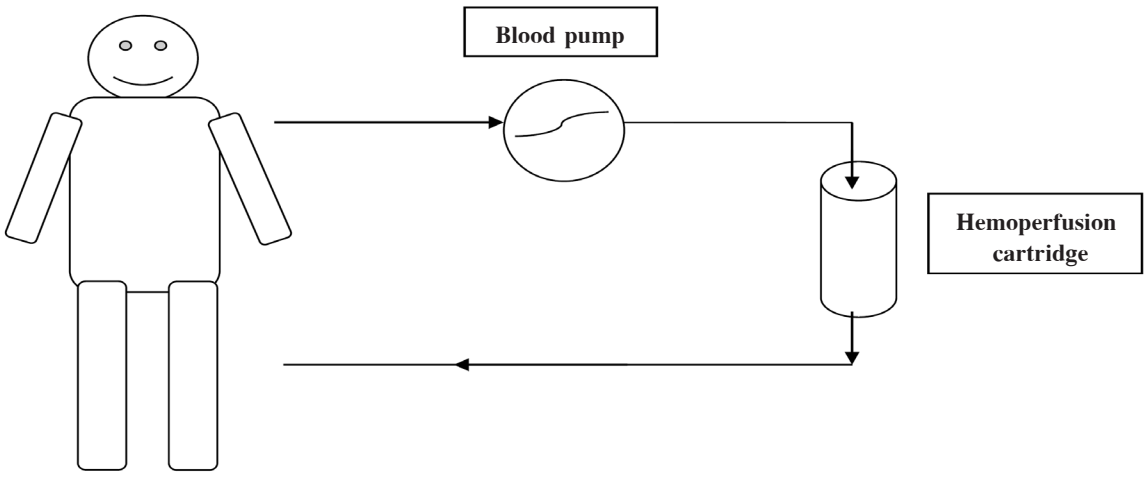
Study Design

We conducted a retrospective study to compare the 30-day survival rate between hemoperfusion and the non-hemoperfusion of severe COVID-19 pneumonia patients who were admitted to the intensive care unit

in Chaophrayayommarat (Pan Sukhum) Suphanburi Hospital from April until October 2021. The patients received standard treatment including antiviral agents, anti-inflammatory agents (corticosteroid), and proper respiratory support. Inclusion criteria were patients aged 18 years old or more, detected SARS-CoV-2 infection by reverse transcriptase polymerase-chain-reaction, diagnosed as severe pneumonia and had the C-reactive protein (CRP) ≥50 mg/L. (severe pneumonia defined as SpO_2 <94% on room temperature, PaO_2/FiO_2<300 mmHg, a respiratory rate >30 breaths/min, or lung infiltrates >50[26]). Exclusion criteria were diagnosis of COVID-19 infection more than 15 days, intractable shock from bacterial sepsis, cardiogenic and massive bleeding, active diseases (of infection e.g. tuberculosis, AIDS, malignancy and immunologic disease) and pregnancy. We defined the patients who received both standard treatment and hemoperfusion as the "study group" (the HP group), while the group of patients who received the standard treatment alone was the "control group" (the non-HP group). The patients in the HP group were cannulated with double lumen catheter via central vein, mainly the internal jugular, and performed hemoperfusion at a blood flow rate of 150-200 mL/min, duration 4 hours, once daily for 3-5 sessions according to clinical adjustment by doctor team. We used HA-330 (Jafron®, Zhuhai, China) for hemoperfusion cartridge. Heparin was not infused in the circuit during the hemoperfusion session due to the concerning of bleeding issue. Hemoperfusion circuit shown in Figure 1.

The study was approved by the Medical Research Committee for Research Ethics of Chaophrayayommarat (Pan Sukhum) Suphanburi Hospital (Certificate No YM024/2565). Laboratory tests were recorded when patients had clinical worsening. Demographic data [sex, age, underlying diseases, body mass index (BMI), number of days from onset of disease to worsening and received high dose steroid or methylprednisolone, ROX index, respiratory support type, P/F ratio, COVID-19 medications], laboratory findings [HCT, WBC count, total lymphocyte count, platelet count, albumin, eGFR, CRP, D-Dimer, procalcitonin] and outcomes [hospital stay day, ICU stay days, ventilator support after the treatment, complications, 7-day survival rate and 30-day survival rate]

Figure 1 Simple hemoperfusion circuit



of patients were retrospectively collected and compared.

Sample size

The main objective of our study was the comparison of 30-day survival rate between the HP and the non-HP group in severe COVID-19 pneumonia patients. Based on the study of Mikaeili H et al.[25] The survival rate between the HP and the non-HP group were found to be 0.629 and 0.364, respectively. We calculated the sample size by two independent proportions from n4 study application, assuming 80% power, type 1 error = 0.05 and the total was 139 patients. For the secondary objective study, we calculated the sample size from the same study.[25] We studied 13 variables hemoperfusion, age, sex, diabetes mellitus, hypertension, dyslipidemia, ROX index, APACHE, procalcitonin, albumin, eGFR, tocilizumab use and anti-fungus use) by Hair JF et al. formula.[27] The number of sample size were 143 patients.

Statistical analysis

Categorical data were summarized using frequency and percentage and compared between groups using the Chi-squared test or Fisher's exact test as appropriate. Continuous data with normally distributed were summarized using mean and standard deviation (SD) and compared between groups using Student's t-test. While continuous data with skewed distribution were summarized using median and interquartile range (IQR) and compared between groups using the Mann-Whitney U test. The comparison within the group was performed using either Paired t-test or Wilcoxson signed-rank test as appropriate.

We summarized the outcome of "survival at day 30" using frequency and percentage and presented with the 95% confidence intervals (CIs) for the HP group and non-HP. We initially compared the outcome between the two groups using the Chi-squared test and then corrected the comparison by performing the multivariable logistic regression on survival at day 30 to adjust for potential factors to the survival rate at day 30 and imbalance between groups. Statistical significance was considered at $p<0.05$. Stata version 14.0 was used for all analyses.

Results

One hundred and thirty-eight severe COVID-19 patients were enrolled, 69 patients were in the HP group and 69 patients were in the Non-HP group, equally. The baseline characteristics of patients were shown (Table 1).

The CRP level was decreased from baseline at day 3 and day 5 in both HP and non-HP groups. On day 3 of enrollment, the CRP level in the HP group was reduced more than in the non-HP group, p=0.032. (Figure 2)

The survival rate at day 30 in the HP group was 58% (95%CI=45-70%) and in non-HP 42% (95%CI=30-55%), p=0.061. For non-intubated patients before treatment, the rate of intubation in HP group was 34% (n=58), and in the non-HP group was 53% (n=57), p=0.05. The median (IQR) ICU length of stay was 11 days (7-14) in the HP group and 10 days (6-13) in the non-HP group with non-statistical significance, p=0.136 (Table 2). In the HP group, the non-intubated patients (n=58) before hemoperfusion have a survival rate of 66% and the intubated patients (n=11) before hemoperfusion have a survival rate of 18%, the difference was statistically significant (p=0.005). (Table 3)

Table 1 The baseline characteristics of patients

Baseline characteristics		HP (N=69)		Non-HP(N=69)		p-value
		Number	%	Number	%	
Sex	Male	36	52	34	49	0.733
	Female	33	48	35	51	
Age (years), mean±SD		57±15		66±14		<0.001
BMI level	Underweight (<18.5)	2	3	3	5	0.432 (f)
	Normal (18.5-24.9)	18	26	26	39	
	Overweight (25-29.9)	24	35	21	30	
	Obese (≥30)	25	36	19	28	
Obesity, n (%)		25	36	19	28	0.273
Comorbidities	Hypertension	35	51	43	62	0.170
	Diabetes	20	29	27	39	0.209
	Dyslipidemia	23	33	23	33	1.000
	Gout	3	4	4	6	1.000 (f)
	CAD	4	6	2	3	0.681 (f)
	Stroke	2	3	2	3	1.000 (f)
	CKD	0	0	4	6	0.120 (f)
	Cancer	3	4	0	0	0.245 (f)
Days from PCR positive to ICU, mean±SD		4.28±2.8		3.77±2.8		0.294
Respiration status:	O_2 high flow	58	84.1	57	82.6	0.819
	Endotracheal tube with mechanical ventilator	11	15.9	12	17.4	
Laboratory test	CRP, median (IQR)	97 (69-135)		86 (67-115)		0.295
	PaO2/Fi O2 ratio, median (IQR)	118 (75-169) (N=69)		114 (76-177) (N=34)		0.553
APACHE, mean±SD		10.5±5 (N=69)		18±7 (N=34)		<0.001
ROX* index, median (IQR)		5 (4-7)		5 (4-7)		0.769
D-Dimer, median (IQR)		522 (351-1,376) (N=56)		917 (368-1,666) (N=54)		0.269
Procalcitonin, median (IQR)		0.15 (0.08-0.38) (N=67)		0.26 (0.14-0.79) (N=66)		0.004
eGFR, mean±SD		96.8±21.0		71.9±28.7		<0.001
Albumin, mean±SD		3.4±0.5 (N=69)		3.7±0.5 (N=68)		0.007
Hematocrit, mean±SD		39.9±6.3		39.0±5.1		0.394
White blood cell (x103), median (IQR)		12.21 (8.45-14.63)		10.51 (7.44-13.94)		0.130
Platelet (x103), median (IQR)		270 (200-335)		222 (173-314)		0.206

*respiratory rate and oxygenation index (ROX index)

(f): Fisher's exact test was performed, otherwise the Chi-squared test.

Figure 2 Follow-up CRP level and change in the HP and the Non-HP group

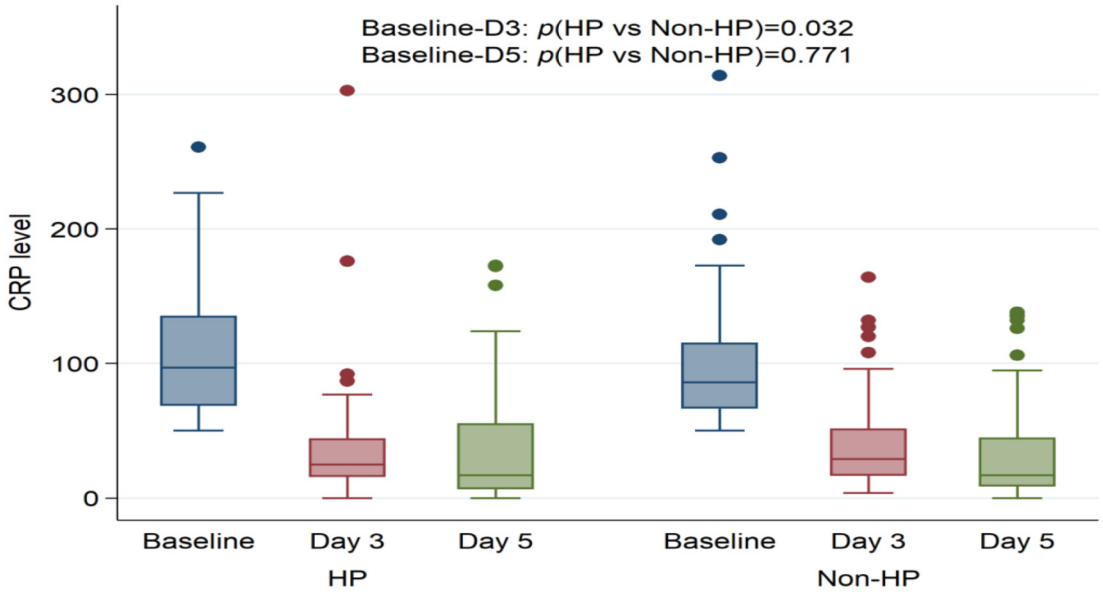


Table 2 Clinical outcomes

Outcomes	HP(N=69)			Non-HP(N=69)			p-value
	Number	%	95%CI	Number	%	95%CI	
Survival rate,							
Day 7	62	90	80-96	60	87	77-94	0.595
Day 30	40	58	45-70	29	42	30-55	0.061
On endotracheal tube after treatment	(N58)			(N57)			
	20	34		30	53		0.050
Hospital length of stay (days), median(IQR)	17 (13-22)			14 (10-18)			0.009
ICU length of stay (days), median (IQR)	11 (7-14)			10 (6-13)			0.136
ICU free days (Hospital - ICU length of stay)	4 (1-11)			3 (0-6)			0.062

Table 3 The comparison of 30-day survival rate in the hemoperfusion (HP) group between on endotracheal tube status or no endotracheal tube status before hemoperfusion performed.

Outcomes	Survive		Dead		p-value
	Number	%	Number	%	
No endotracheal tube before HP (n58)	38	66	20	34	0.005
On Endotracheal tube before HP (n11)	2	18	9	82	
Total	40		29		

Fisher's exact test

Multivariable logistic regression adjusted for baseline characteristics is shown in Table 4. To compare the 30-day survival rate between the HP and the non-HP groups, we found factors associated with survival rate between the 2 groups were age, comorbidity (diabetes mellitus, hypertension), procalcitonin, albumin, ROX index, antifungal and tocilizumab use. These factors were analyzed and had not associated with survival status between both groups (adjusted odds ratio 1.40 (95%CI=0.49-4.00; p=0.531)).

Other significant variables independently associated were age (adjusted odds ratio 0.94 (95%CI=0.91-0.98; p=0.003)) and ROX index level (adjusted odds ratio 2.20 (95%CI=1.55-3.12; p<0.001)).

Our study had one complication, the patient developed pneumothorax after double-lumen catheter cannulation in the right internal jugular vein. The intercostal drainage was done immediately. This patient received hemoperfusion for four sessions and survived. Every patient in our study had the hospital acquired infection and received proper intravenous antibiotics.

Table 4. Comparison of day 30 survival rate in HP and non-HP patients adjusted for baseline characteristics

Characteristics	Outcome day 30, Survive (N=69)		Dead (N=69)		Univariate analysis on survival day 30		Multivariable analysis on survival day 30	
	Number	%	Number	%	Odds ratio (95%CI)	p-value	Adjusted Odds Ratio (95%CI)	p-value
Patient's group								
- HP	40	58	29	42	1.90 (0.97-3.74)	0.062	1.40 (0.49, 4.00)	0.531
- Non-HP	29	42	40	58	Reference		Reference	
Age (years), mean±SD	55±14		67±14		0.94 (0.91-0.97)	<0.001	0.94 (0.91-0.98)	0.003
Male (vs female)	38	55	32	46	1.42 (0.73-2.77)	0.308	-	-
Hypertension, %	29	42	49	71	0.30 (0.15-0.60)	0.001	0.72 (0.25-2.10)	0.547
Diabetes, %	18	26	29	42	0.49 (0.24-1.00)	0.050	1.05 (0.34-3.21)	0.935
Dyslipidemia, %	20	29	26	38	0.68 (0.33-1.38)	0.280	-	-
APACHE, mean±SD	(N=44)		(N=59)					
	9.6±4.2		15.5±7.1		0.82 (0.74-0.90)	<0.001	NA	NA
Procalcitonin, median (IQR)	(N=68)		(N=65)					
	0.17		0.23		0.29 (0.12-0.71)	0.007	0.41 (0.16-1.05)	0.064
	(0.08-0.40)		(0.14-1.28)					
eGFR (mL/min/1.73m^2)	95±22		74±29		1.03 (1.02-1.05)	<0.001	NA	NA
Albumin (mg/dL), mean±SD	3.55±0.39		3.37±0.44		2.91 (1.23-6.86)	0.015	2.42 (0.89-6.55)	0.083
ROX, mean±SD	6.8±2.2		4.6±1.3		2.17 (1.63-2.89)	<0.001	2.20 (1.55-3.12)	<0.001
Antifungal agent use	7	10	14	20	0.44 (0.17-1.18)	0.103	-	-
Tocilizumab use	7	10	3	4	2.48 (0.61-10.0)	0.202	-	-

Remark: APACHEII was not included in the multivariable analysis because there were many missing APACHE values. This would result in decreased number of observations in the multivariable analysis when including it. eGFR was not included in the multivariable analysis because it was highly correlated with age.

Discussions

This was a retrospective study in severe COVID-19 pneumonia and had CRP level ≥50 mg/L to compare 30-day survival rate between standard treatment with hemoperfusion (HP) and standard treatment with non-hemoperfusion (non-HP). We are unable to use the IL-6 for biomarker for inflammatory response as our laboratories are not available and high cost. So we use the CRP instead of IL-6 as we have shown that the CRP, the non-specific acute phase reactant associated to IL-6.[28] The CRP decreased in both groups on days 3 and 5 from baseline with significant statistics ($p<0.001$). On day 3 in the HP group, CRP decreased from the baseline more than the non-HP group $p = 0.032$. These findings were consistent with the study in the past.[13,14]

The 30-day survival rate in the HP group was 58% and 42% in the non-HP group, it was not significant ($p = 0.061$) but the tendency of survival rate were higher in the HP group. Soleimani A et al. were retrospective studies in severe COVID-19 infection in ICU. They compared between the HP group and the conventional antiviral group. The results were that HP did not effect on mortality significantly (the survival rate in the HP group was 79% and in the conventional group was 67%) but the HP can improve respiratory distress.[13] They designed only three sessions of hemoperfusion and some patients had HA-280 which was different from our study. Chitty SA et al. demonstrated a retrospective cohort match control study. They found that the mortality was lower in the hemoperfusion-treated group compared with controls but not compared with an external cohort.[29] The difference from our study were such as characteristic of the Seraph-100 cartridge, some patients who had a septic shock or multiple organ dysfunction were included and age more than 75 was excluded from their study.

Ilad AD et al. conducted matched control retrospective study. The mortality rate in the hemoperfusion group was lower than the matched control group, 67.3% and 89% respectively and had statistically significant ($p=0.002$).[15] Some patients had Cytosorb-300 (hemoperfusion cartridge) and continuous renal replacement therapy (CRRT) in their study, these could increase the effectiveness of extracorporeal blood purification.

Surasit K et al. studied prospective cohort design, they found that the survival rate on day 28 in the hemoperfusion group better than in the control group significantly.[24] This result might be from the inclusion of hemoperfusion of less than 3 sessions in the control group and enrolled CRP ≥30 mg/Lt. So, this possibly confirmed the benefit of hemoperfusion in the early stage of severe COVID-19 pneumonia.

The rate of intubation after hemoperfusion in the HP group was 34.5% and in the non-HP group was 52.6% ($p = 0.05$). Although this was not a difference in statistics the tendency was better in the HP group than the non-HP group. Rifkin BS et al. reported hemoperfusion in early severe COVID-19 patients with Seraph-100, all were not intubated and survived. But it was only four patients in the study and no control group compared.[16] Interestingly, we found that if the patients had respiratory failure and were intubated before hemoperfusion, the 30-day survival rate was 18.2% compared to the patients who had not intubation before hemoperfusion was 65.5%, $p=0.005$. Thus, in the early stage (not intubated patients) of severe COVID-19 pneumonia, hemoperfusion might show more benefit than the late stage of the disease

(intubated patients). As to confirm this outcome, Saeed A et al. showed that hemoperfusion before the intubation reduced the need for a mechanical ventilator and the mortality rate was significantly higher in patients who had hemoperfusion after undergoing mechanical ventilator. [17] Moreover, Mikaeili H et al. noticed a significant mortality rate reduction in the hemoperfusion compared with control, this positive effect was stronger among those with a PaO_2/FiO_2 ratio higher than 75 ($p = 0.02$). They imply that the early start of hemoperfusion could be more effective and significantly reduce the mortality rate among COVID-19 patients with critical diseases.[25] In our study, we did not use PaO_2/FiO_2 ratio because of the lack of this data due to retrospective study but we evaluated ROX index instead. We reported that the patients who had the higher ROX index, the more survival rate than lower ROX index significantly. The PaO_2/FiO_2 ratio correlates with similar linear relationship to SpO_2/FiO_2.[30] We confirmed that hemoperfusion in early severe COVID-19 pneumonia had more advantages than late severe stage.

The median ICU length of stay in the HP group was 11 days whiles the non-HP group was 10 days, p=0.136. In the previous discussion, it was different in statistically significant between HP and Non-HP, 12 days and 8 days respectively, p<0.001.[15] The continuous renal replacement therapy (CRRT), the other extracorporeal blood purification in HP group was done in some patients thus it could affect to ICU stay. To explain the reason, further appropriate studies should be designed. In our study there was a serious adverse event in one patient after vascular access cannulation in an internal jugular vein. The patient developed pneumothorax and was performed a chest tube thoracostomy once detected. Fortunately, the patient was well tolerated and survived.

Many experimental researches about hemoperfusion were different in the study protocols but the objective of those studies was to control cytokine storms besides the standard treatment guideline. We believe that early hemoperfusion is more benefit than late initiation, but this need issue be further studied by specific design study. The strength of our study was the numbers of sample size, level of severity of pneumonia which CRP exceeds than 50 mg/L and can adapted for general hospitals. With the limitation of our retrospective study, we cannot conclude the causal effect of HP in severe COVID-19 infection.

Summary

The 30-day survival rate in severe COVID-19 pneumonia patients who received standard treatment and HP was higher than in standard treatment alone however it did not reach statistical significance. We also demonstrate the safety profile of HP. The rate of intubation was also lower after HP. Finally, our study suggested that HP should be considered in the early stage of the severity especially before intubation.

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บทคัดย่อ: การเปรียบเทียบอัตราการรอดชีวิตที่ 30 วัน ระหว่างกลุ่มที่ได้รับการทำฮีโมเพอรฟิวชั่นกับไม่ได้ทำฮีโมเพอรฟิวชั่นในผู้ป่วยปอดอักเสบติดเชื้อโควิด-19 ที่มีอาการรุนแรง

วนิดา สมบูรณ์ศิลป์ พ.บ.*; วีรภัทร พาพันธุ์เรือง พ.บ.*; สุรศักดิ์ ถิระภัทรพันธุ์ พ.บ.*; ณัฐชัย ศรีสวัสดิ์ พ.บ.**

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วารสารวิชาการสาธารณสุข 2566;32(เพิ่มเติม 1):S182-S194.

ปอดอักเสบที่เกิดจากการติดเชื้อโควิด-19 อย่างรุนแรงทำให้ผู้ป่วยมีโอกาสเสียชีวิตมากขึ้นแม้ว่าผู้ป่วยจะได้รับรักษาด้วยวิธีมาตรฐานแล้วอันเป็นผลเนื่องมาจากภาวะพายุไซโตไคน์ มีการศึกษาพบว่าฮีโมเพอรฟิวชั่นสามารถขจัดสารไซโตไคน์ได้อย่างมีประสิทธิภาพ จึงอาจเป็นทางเลือกหนึ่งที่ช่วยให้ผู้ป่วยมีโอกาส รอดชีวิตและลดการเกิดภาวะแทรกซ้อนต่าง ๆ ได้ การวิจัยแบบ retrospective study นี้มีวัตถุประสงค์เพื่อเปรียบเทียบอัตราการรอดชีวิตที่ 30 วันของผู้ป่วยปอดอักเสบติดเชื้อโควิด-19 ที่มีอาการรุนแรงระหว่างกลุ่มที่ได้รับการทำฮีโมเพอรฟิวชั่นกับไม่ได้ทำฮีโมเพอรฟิวชั่น กลุ่มตัวอย่างเป็นผู้ป่วยปอดอักเสบจากการติดเชื้อโควิด-19 อย่างรุนแรง จำนวน 138 ราย ที่เข้ารับการรักษาในหอผู้ป่วยวิกฤต โรงพยาบาลศูนย์เจ้าพระยายมราช (ปั้น สุขุม) จังหวัดสุพรรณบุรี ตั้งแต่เดือนเมษายนถึงตุลาคม พ.ศ.2564 ที่มีอายุตั้งแต่ 18 ปีขึ้นไป ได้รับการวินิจฉัยปอดอักเสบจากการติดเชื้อโควิด-19 อย่างรุนแรง และมีค่า C-reactive protein (CRP) ตั้งแต่ 50 มิลลิกรัม/ลิตรขึ้นไป ซึ่งแบ่งเป็นกลุ่มที่ได้รับยาตามมาตรฐานร่วมกับการทำ HP 3-5 ครั้ง จำนวน 69 ราย (HP) และกลุ่มที่ได้รับยาตามมาตรฐาน จำนวน 69 ราย (non-HP) ผลการศึกษาอัตราการรอดชีวิตที่ 30 วันของผู้ป่วยกลุ่ม HP เท่ากับร้อยละ 58 (95%CI 45-70%) และกลุ่ม Non-HP เท่ากับร้อยละ 42 (95%CI 30-55%) ซึ่งไม่แตกต่างอย่างมีนัยสำคัญทางสถิติ ($p>0.05$) ระดับ CRP ที่ 3 วัน ในกลุ่ม HP ลดลงมากกว่ากลุ่ม Non-HP อย่างมีนัยสำคัญทางสถิติ ($p<0.05$) เมื่อเปรียบเทียบผู้ป่วยที่ยังไม่ได้ใส่ท่อช่วยหายใจก่อนการรักษา ระหว่างกลุ่ม HP และ Non-HP พบว่ามีอัตราการถูกใส่ท่อช่วยหายใจหลังเข้ารับการศึกษาเท่ากับร้อยละ 34.5 และ 52.6 ตามลำดับ ($p<0.05$) ในกลุ่ม HP เมื่อเปรียบเทียบอัตราการรอดชีวิตที่ 30 วันระหว่างผู้ที่ได้รับการใส่ท่อช่วยหายใจและยังไม่ได้ใส่ท่อช่วยหายใจก่อนทำฮีโมเพอรฟิวชั่นอัตราการรอดชีวิตที่ 30 วันเท่ากับร้อยละ 18.2 และเท่ากับร้อยละ 65.5 ตามลำดับ ($p=0.05$) พบว่า อายุ [adjusted odds ratio 0.94 (95%CI 0.91-0.98; $p<0.05$)] และค่า ROX [adjusted odds ratio 2.20 (95%CI 1.55-3.12; $p<0.001$] มีความสัมพันธ์อย่างเป็นอิสระกับอัตราการรอดชีวิตที่ 30 วัน อย่างมีนัยสำคัญจากผลการศึกษาสรุปว่าอัตราการรอดชีวิตที่ 30 วันในผู้ป่วยปอดอักเสบ ติดเชื้อโควิด-19 อย่างรุนแรงที่ได้รับการทำ ฮีโมเพอรฟิวชั่นร่วมกับการรักษามาตรฐานสูงกว่าได้รับการรักษาตามมาตรฐานเพียงอย่างเดียว และอัตราการใส่ท่อช่วยหายใจในกลุ่มที่ทำฮีโมเพอรฟิวชั่นต่ำกว่ากลุ่มที่ไม่ได้ทำฮีโมเพอรฟิวชั่นด้วยควรมีการศึกษาเพิ่มเติมแบบ randomized control trial ในอนาคตต่อไป

คำสำคัญ: **ปอดอักเสบติดเชื้อโควิด-19 อย่างรุนแรง; พายุไซโตไคน์; ฮีโมเพอรฟิวชั่น**