Role and Prognosis of Extracorporeal Life Support in Patients Who Develop Cardiac Arrest during or after Office-Based Cosmetic Surgery

Seong Soon Kwon, M.D.[1], Byoung-Won Park, M.D., Ph.D.[1], Min-Ho Lee, M.D.[1], Duk Won Bang, M.D., Ph.D.[1], Min-Su Hyon, M.D., Ph.D.[1], Won-Ho Chang, M.D., Ph.D.[2], Hong Chul Oh, M.D.[2], Young Woo Park, M.D., Ph.D.[2]

[1]Division of Cardiology, Department of Internal Medicine and [2]Department of Chest Surgery, Soonchunhyang University Seoul Hospital, Seoul, Korea

Background: Cardiac arrest during or after office-based cosmetic surgery is rare, and little is known about its prognosis. We assessed the clinical outcomes of patients who developed cardiac arrest during or after cosmetic surgery at office-based clinics.
Methods: Between May 2009 and May 2016, 32 patients who developed cardiac arrest during or after treatment at cosmetic surgery clinics were consecutively enrolled. We compared clinical outcomes, including complications, between survivors (n=19) and non-survivors (n=13) and attempted to determine the prognostic factors of mortality.
Results: All 32 of the patients were female, with a mean age of 30.40±11.87 years. Of the 32 patients, 13 (41%) died. Extracorporeal life support (ECLS) was applied in a greater percentage of non-survivors than survivors (92.3% vs. 47.4%, respectively; p=0.009). The mean duration of in-hospital cardiopulmonary resuscitation (CPR) was longer for the non-survivors than the survivors (31.55±33 minutes vs. 7.59±9.07 minutes, respectively; p=0.01). The mean Acute Physiology and Chronic Health Evaluation score was also higher among non-survivors than survivors (23.85±6.68 vs. 16.79±7.44, respectively; p=0.01). No predictor of death was identified in the patients for whom ECLS was applied. Of the 19 survivors, 10 (52.6%) had hypoxic brain damage, and 1 (5.3%) had permanent lower leg ischemia. Logistic regression analyses revealed that the estimated glomerular filtration rate was a predictor of mortality.
Conclusion: Patients who developed cardiac arrest during or after cosmetic surgery at office-based clinics experienced poor prognoses, even though ECLS was applied in most cases. The survivors suffered serious complications. Careful monitoring of subjects and active CPR (when necessary) in cosmetic surgery clinics may be essential.

Keywords: Plastic surgery, Cardiac arrest, Extracorporeal circulation

Introduction

Extracorporeal life support (ECLS) is a modification of the cardiopulmonary bypass circuit that is commonly used in various critical cardiac situations [1], including post-cardiotomy, post-heart transplantation, after the development of severe cardiac failure attributable to decompensated cardiomyopathy, in patients with myocarditis, in patients with acute coronary syndrome accompanied by cardiogenic shock, and in patients exhibiting cardiac depression attributable to drug overdose or sepsis. A form of ECLS termed extracorporeal cardiopulmonary resuscitation (CPR) is also used in cases of cardiac arrest [2]. ECLS is becoming an increasingly popular treatment for adults with cardiac and/or respiratory failure, as its outcomes have improved over time. The survival rates of adults with cardiac and respiratory failure are 39% and 55%, respectively [3]. However, the rate of survival after out-of-hospital cardiac arrest (OHCA) remains poor [4]. The prognostic factors for poor outcomes (including mortality) are advanced age, stroke, renal failure, acidosis, and hypoglycemia [5].

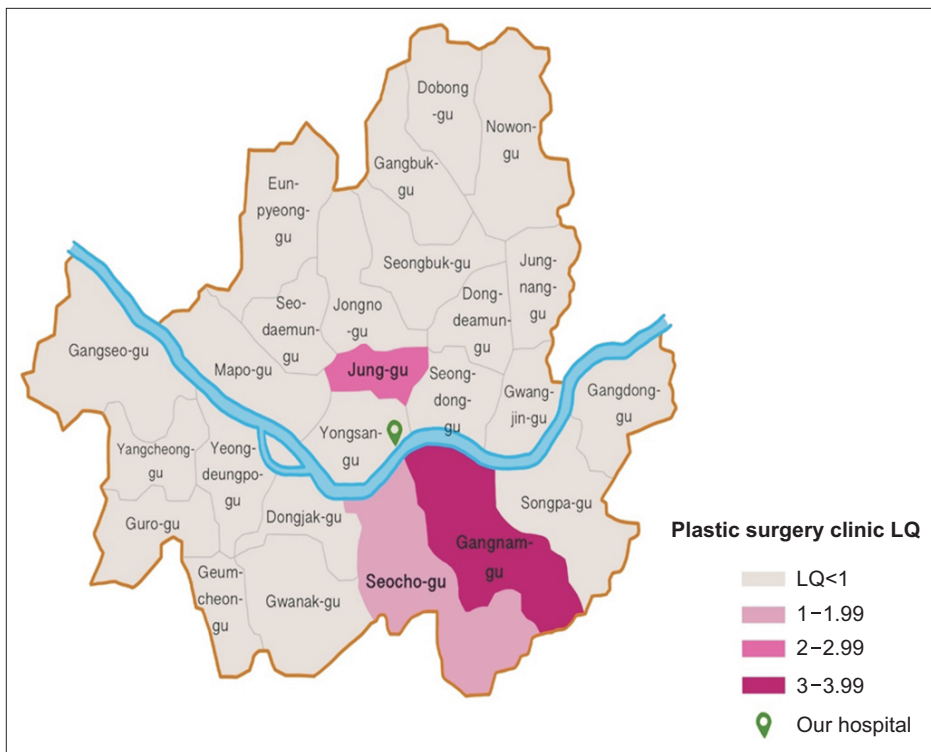Cardiac arrest during non-cardiac surgery is rare. In a

Fig. 1. Regional distribution of plastic surgery clinic and location of Soonchunhyang University Seoul Hospital. LQ, location quotient (a simple tool used to determine the spatial distribution of a particular industry, cluster, occupation, or demographic group).

recent study, the incidence was 7.22 cases per 10,000, and the 30-day mortality rate was 63% [6]. The risk of cardiac arrest during or after surgery increases with advanced age, impaired functional status, the presence of comorbidities, the level of surgical risk, and the need for blood transfusion [6]. A quality assurance program administered by the American Association for Accreditation of Ambulatory Surgery Facilities in the accredited facilities of that organization included more than 1 million outpatient procedures performed between 2001 and 2006 and reported a mortality rate of 0.002% [7]. However, little is known regarding the risk of complications or overall prognosis of patients who develop cardiac arrest during or after office-based cosmetic surgery.

We retrospectively reviewed our 8-year data on patients who developed cardiac arrest during or after office-based cosmetic surgery with the objectives of identifying the mortality and complication rates after the use of ECLS and defining factors that predict survival.

Methods

Between May 2009 and May 2016, we enrolled and retrospectively reviewed 32 consecutive patients who developed cardiac arrest during or after cosmetic surgery at primary clinics. A total of 21 patients underwent ECLS to treat re-

fractory cardiac arrest and/or shock. Our hospital is located near more than 200 office-based cosmetic surgery clinics that are within 15–20 minutes' drive by ambulance (Fig. 1) [8]. The baseline clinical characteristics, types of cosmetic surgery, and types of anesthesia employed were reviewed, in addition to the duration of CPR, the time interval between cardiac arrest and arrival at our hospital, the Acute Physiology and Chronic Health Evaluation (APACHE) score, and propofol usage. However, we lacked information regarding both the doses of anesthetic agents administered and the surgical duration.

The 32 patients were divided into those who survived and were discharged (survivors, n=19) and those who died in the hospital (non-survivors, n=13). Two extracorporeal systems were employed. The first featured a centrifugal pump; a polypropylene, hollow-fiber membrane oxygenator; and a heparin-coated circuit (Capiox EBS circuit; Terumo Inc., Tokyo, Japan). The second included a Rotaflow centrifugal pump and a Quadrox PLS oxygenator (Maquet, Hirrlingen, Germany). Arterial cannulae (14F–22F) were percutaneously inserted into the femoral artery using the Seldinger technique. Heparin (5,000 U) was administered 5 minutes prior to femoral arterial cannulation. Once the cannula was in place, the ECLS system was activated. Percutaneous femoral ECLS was instituted in the emergency room while CPR was being administered or after the re-

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Table 1. Baseline characteristics of all patients and comparison between survivors and non-survivors

| Characteristic | All (n=32) | Survival | | p-value |
		Yes (n=19)	No (n=13)	
Clinical				
Age (yr)	30.40±11.87	29.58±7.71	33.54±14.99	0.334
Extracorporeal life support applied	21 (65.6)	9 (47.4)	12 (92.3)	0.009
Out-of-hospital arrest	27 (84.4)	14 (73.7)	13 (100.0)	0.064
Pulmonary edema	16 (50)	7 (36.8)	9 (69.2)	0.072
Cardiopulmonary resuscitation duration at hospital (min)	17±24.81	7.59±9.07	31.55±33.87	0.010
Acute Physiology and Chronic Health Evaluation	19.66±7.86	16.79±7.44	23.85±6.68	0.010
Left ventricular ejection fraction (%)	40.59±19.24	45.0 ±18.91	33.36±18.32	0.115
Survival time (day)			18.2±33.7	
Time interval between cardiac arrest and arrival at the hospital (min)	49±75	64±93	27±20	0.039
Anesthesia				0.266
Local	11 (35)	8 (42)	3 (23)	
General	21 (65)	11 (58)	10 (77)	
Propofol	20 (63)	11 (58)	9 (69)	0.515
Laboratory (initial)				
pH	7.12±0.23	7.21±0.19	6.99±0.22	0.006
Partial pressure of oxygen (mm Hg)	109.41±119.32	143.37±143.56	62.39±47.62	0.061
Partial pressure of carbon dioxide (mm Hg)	78.13±110.33	87.71±142.99	64.86±33.69	0.578
Bicarbonate (mmol/L)	24.6±15.64	16.18±7.78	14.89±6.02	0.291
Total carbon dioxide (mmol/L)	15.06±7.01	16.26±4.50	13.31±4.80	0.086
Serum creatinine (mg/dL)	1.6±0.87	0.79±0.13	0.97±0.26	0.015
Estimated glomerular filtration rate (mL/min)	92.89±20.38	99.98±17.04	82.53±21.0	0.015
Hemoglobin (g/dL)	13.27±1.86	13.44±1.57	12.27±1.20	0.031
Hematocrit (%)	39.65±4.88	41.10±4.88	37.52±4.18	0.040
Creatine kinase-MB (ng/mL)	3.78±3.86	4.35±4.86	2.93±1.36	0.316
Troponin T (ng/mL)	0.39±0.08	0.11±0.12	0.04±0.06	0.086

Values are presented as mean±standard deviation for continuous variables and number (%) for categorical variables.

turn of spontaneous circulation. If not contraindicated, low-molecular-weight or unfractionated heparin was given to reduce the risk of thromboembolic complications during ECLS. The activated partial thromboplastin time was monitored at least every 6–12 hours, and the intravenous heparin infusion rate was 12–15 U/kg/hr in all cases. No patient underwent distal perfusion to prevent lower leg ischemia. At each weaning attempt, transthoracic echocardiography was used to monitor heart function. During weaning, the flow was gradually reduced to 1 L/min/m^2. Inotropic agents were used to facilitate weaning in most cases. Patients who maintained adequate ventricular function and exhibited stable vital signs were decannulated [9].

The results for continuous variables are reported as means±standard deviations, whereas the results for categorical variables are presented as frequencies and percentages. Comparisons between continuous variables were made using the Student t-test, while comparisons between categorical variables were evaluated using the Fisher exact test or the Pearson chi-square test, as appropriate. Survival analysis was performed using Kaplan-Meier analysis. Vari-

ables with p<0.2 were entered into the multivariable logistic regression analysis to calculate the odds ratios (ORs) and 95% confidence intervals (CIs). A p-value <0.05 was considered to indicate a statistically significant difference. All statistical analyses were performed using IBM SPSS ver. 21.0 (IBM Corp., Armonk, NY, USA). This study was performed in accordance with the ethical guidelines of the 1975 Declaration of Helsinki and was approved by the Institutional Review Board of Soonchunhyang University Seoul Hospital (SCHUH 2019-01-009). Due to the retrospective nature of this study, informed consent was not required.

Results

Patient characteristics

The baseline characteristics and clinical features of all 32 patients are summarized in Table 1. All were female, with a mean age of 30.40±11.87 years. The types of plastic surgery performed were liposuction (n=12), rhinoplasty (n=5),

Table 2. Characteristics of patients who received ECLS

Characteristic	All (n=21)	Survival		p-value
		Yes (n=9)	No (n=12)	
Age (yr)	31.14±12.31	21.56±8.09	32.33±14.98	0.622
Initial rhythm				
Asystole	13 (60.90)	7 (77.78)	6 (50.00)	-
Pulseless electrical activity	2 (9.52)	0	2 (16.67)	-
Shockable rhythm	6 (28.57)	2 (22.22)	4 (33.33)	-
Bystander initiated cardiopulmonary resuscitation	21 (100.00)	9 (100.00)	12 (100.00)	-
Time from cardiac arrest to ECLS initiation[a]	97.12±142.29	35.14±7.01	140.50±175.73	0.091

Values are presented as mean±standard deviation or number (%).
ECLS, extracorporeal life support.
[a]Time of cardiac arrest was defined as the time of arrival to the emergency room of Soonchunhyang University Seoul Hospital.

breast augmentation (n=5), maxillofacial surgery (n=5), scar revision (n=3), facelift (n=1), and hair transplantation (n=1). Of the 32 patients, 13 died (41%). ECLS was used in a total of 21 patients (65.6%). The mean age of the survivors was 29.58±7.71 years, while that of the non-survivors was 33.54±14.99 years. ECLS was applied in a greater percentage of non-survivors than survivors (92.3% versus 47.4%, respectively; p=0.009). No predictor of death was identified in the patients for whom ECLS was applied. The characteristics of patients who received ECLS are shown in Table 2. Neither the OHCA rate nor the extent of pulmonary edema evident on chest X-ray differed significantly between the survivors and the non-survivors. The mean in-hospital CPR duration was longer in the non-survivors than in the survivors (31.55±33.87 minutes in non-survivors versus 7.59±9.07 minutes in survivors, p=0.01). The APACHE score was also higher in non-survivors than in survivors (23.85±6.68 versus 16.79±7.44, respectively; p=0.01). Finally, the time taken to arrive at the hospital was similarly longer in non-survivors than in survivors (64±93 minutes versus 27±20 minutes, respectively; p=0.039). The left ventricular ejection fraction did not differ significantly between the 2 groups. A total of 11 (35%) and 21 (65%) patients underwent local and general anesthesia, respectively. Propofol was administered to 20 patients (63%). Neither the anesthesia type nor the frequency of propofol usage differed significantly between groups. Blood pH, serum creatinine and hemoglobin levels, and hematocrit were lower in the non-survivors than in the survivors. The other laboratory findings did not differ significantly between groups.

Complications in survivors

The characteristics according to the presence or absence of complications among survivors are shown in Table 3.

Survivors with complications tended to be older (mean age, 32.9±8.3 years in patients with complications versus 25.9±5.2 years in patients with no complications; p=0.044), to have had OHCA (100% in patients with complications versus 44.4% in patients with no complications, p=0.006), and had a longer mean CPR duration (14.0±9.6 minutes in patients with complications versus 1.9±2.4 minutes in patients with no complications, p=0.002). The frequency of ECLS application, the APACHE score, and the type of anesthesia employed did not differ significantly between groups. With the exception of troponin T levels, the laboratory data also lacked significant differences between groups.

Analysis of mortality

The Kaplan-Meier curves showed that mortality was significantly higher in patients for whom ECLS was applied (n=21) than in those for whom ECLS was not applied (n=11) (log-rank p=0.026) (Fig. 2).

Univariable logistic regression analysis showed that ECLS application (OR, 13.333; 95% CI, 1.434–123.989; p=0.023), CPR duration (OR, 1.091; 95% CI, 0.998–1.120; p=0.025), pH (OR, 0.006; 95% CI, 0.000–0.377; p=0.016), APACHE score (OR, 1.164; 95% CI, 1.022–1.326; p=0.022), estimated glomerular filtration rate (eGFR; OR, 0.949; 95% CI, 0.907–0.994; p=0.027), and glucose levels (OR, 1.005; 95% CI, 1.000–1.011; p=0.045) were associated with mortality. In the multivariable logistic analysis, which included variables with p-values <0.2, eGFR was the only significant predictor of mortality (OR, 0.925; 95% CI, 0.864–0.990; p=0.025) (Table 4).

Discussion

We found that patients entering cardiac arrest during or

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Table 3. Comparison between patients who did and did not experience complications

Characteristic	Complications		p-value
	Yes (n=10)	No (n=9)	
Clinical			
Age (yr)	32.9±8.3	25.9±5.2	0.044
Extracorporeal life support applied	5 (50.0)	4 (44.4)	0.809
Out-of-hospital arrest	10 (100.0)	4 (44.4)	0.006
Pulmonary edema	3 (30.0)	4 (44.4)	0.515
Cardiopulmonary resuscitation duration at hospital (min)	14.0±9.6	1.9±2.4	0.002
Time interval (min)	55±58	74±128	0.710
Anesthesia			0.463
Local	5 (50.0)	3 (33.3)	
General	5 (50.0)	6 (66.7)	
Propofol	6 (60.0)	5 (55.6)	0.845
Acute Physiology and Chronic Health Evaluation	19.5±5.9	13.8±8.1	0.095
Left ventricular ejection fraction (%)	50.7±14.8	39.3±21.6	0.213
Laboratory (initial)			
pH	7.2±0.2	7.3±0.2	0.337
Partial pressure of oxygen (mm Hg)	104.6±47.8	79.4±55.5	0.091
Partial pressure of carbon dioxide (mm Hg)	50.8±29.9	58.9±35.3	0.603
Bicarbonate (mmol/L)	16.4±5.9	15.9±10.1	0.881
Total carbon dioxide (mmol/L)	14.9±4.9	17.8±3.7	0.170
Serum creatinine (mg/dL)	0.81±0.1	0.78±0.1	0.582
Estimated glomerular filtration rate (mL/min)	95.1±15.6	105.4±17.8	0.193
Hemoglobin (g/dL)	13.3±1.4	13.6±1.8	0.679
Hematocrit (%)	40.8±4.6	41.5±5.5	0.756
Creatine kinase-MB (ng/mL)	2.5±1.0	6.4±6.6	0.085
Troponin T (ng/mL)	0.03±0.03	0.19±0.13	0.002

Values are presented as mean±standard deviation for continuous variables and number (%) for categorical variables.
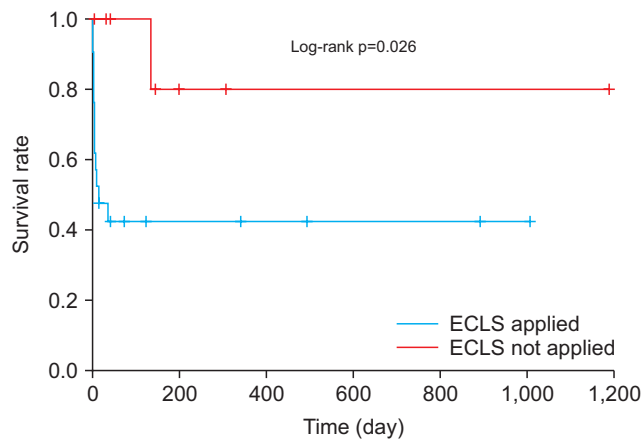

Fig. 2. Kaplan-Meier estimates for overall survival stratified according to whether ECLS was applied. Crosses indicate censored events. ECLS, extracorporeal life support.

soon after cosmetic surgery exhibited poor prognoses (overall mortality rate, 41%), even though ECLS was applied in most cases. Of the survivors, 69% had serious complications, including hypoxic brain damage and lower leg ischemia. This study revealed that eGFR was a significant clinical predictor of mortality, and CPR duration was also an important factor associated with mortality.

Although ECLS is often used to treat OHCA, the outcomes are poor [4]. Recent studies have found a survival rate of >30% among patients with OHCA who received ECLS [10,11]. The prognosis is affected primarily by the underlying cause of OHCA. A recent study suggested that ECLS was a useful rescue strategy for select patients with refractory OHCA, but a multidisciplinary team approach was required [12]. In the present study, despite prolonged CPR (>30 minutes), ECLS was performed in almost all of the patients because they were young and had no underlying disease.

Although cardiac arrest during office-based cosmetic surgery is uncommon, additional studies are needed due to the high level of associated mortality [13]. A retrospective analysis of a resuscitation registry containing data on 2,524 cardiopulmonary arrest patients treated in compliance with current guidelines revealed that the prognosis was poor, the survival-to-discharge rate was low (31.7%), and

Table 4. Univariable and multivariable analysis for the prediction of mortality

Variable	Univariable analysis		Multivariable analysis	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Age	1.033 (0.968–1.103)	0.328		
Extracorporeal life support applied	13.333 (1.434–123.989)	0.023	1.112 (0.048–25.875)	0.947
Time interval	1.042 (0.967–1.122)	0.283		
Cardiopulmonary resuscitation duration	1.091 (1.011–1.177)	0.025	1.057 (0.998–1.120)	0.058
pH	0.006 (0.000–0.377)	0.016	0.017 (0.000–6.648)	0.181
Partial pressure of oxygen	0.988 (0.974–1.002)	0.106		
Partial pressure of carbon dioxide	0.998 (0.989–1.006)	0.583		
Bicarbonate	0.973 (0.878–1.080)	0.610		
Systolic blood pressure	0.993 (0.969–1.017)	0.550		
Pulse rate	0.991 (0.969–1.013)	0.431		
Respiration rate	1.018 (0.963–1.077)	0.529		
Body temperature	0.779 (0.377–1.609)	0.500		
Acute Physiology and Chronic Health Evaluation score	1.164 (1.022–1.326)	0.022	1.152 (0.894–1.484)	0.276
Creatine kinase-MB	0.862 (0.629–1.182)	0.357		
Potassium	0.974 (0.434–2.188)	0.950		
Total carbon dioxide	0.867 (0.734–1.024)	0.092		
Estimated glomerular filtration rate	0.949 (0.907–0.994)	0.027	0.925 (0.864–0.990)	0.025
Glucose	1.005 (1.000–1.011)	0.045	1.000 (0.993–1.007)	0.984
White blood cell count	1.000 (1.000–1.000)	0.292		
Hemoglobin	0.495 (0.243–1.010)	0.053		
Platelet	0.988 (0.975–1.002)	0.092		
Left ventricular ejection fraction	0.965 (0.922–1.010)	0.122		
Pulmonary edema	0.259 (0.058–1.164)	0.078		

OR, odds ratio; CI, confidence interval.

neurological sequelae were common (36%) [14]. Bitar et al. [15] reported that office-based cosmetic surgery performed under monitored anesthesia and sedation in 3,615 patients was not associated with mortality or serious complications. However, another study using 10-year data on office-based surgical procedures performed in Florida reported 46 deaths and 263 procedure-related complications, most of which were associated with elective and cosmetic procedures (56.5% and 49.8%, respectively) [16]. Cosmetic surgery is very popular in Korea; based on an evaluation conducted by the International Society of Aesthetic Plastic Surgery, in 2014, the country had the third-largest number of plastic surgery procedures performed in the world [17]. Because most patients are very healthy young women, no serious safety concerns have arisen. Although the survival rate noted in this study is much higher than that in previous studies, it is essential to recognize the devastating outcomes of OHCA in healthy young patients. It is remarkable that serious complications, including death, neurological sequelae, and lower limb ischemia, develop in healthy young patients entering OHCA during or soon after office-based cosmetic surgery. In our study, hypoxic brain damage occurred frequently in patients with OHCA and a

relatively long CPR duration. In survivors without complications, the troponin T level was high and (although not statistically significant) the left ventricular ejection fraction was low relative to survivors with complications. From this, it is assumed that the duration of exposure to hypoxia is more important than the extent of heart damage in the occurrence of brain damage after cardiac arrest.

The causes and pathogenesis of OHCA of this nature remain poorly characterized. First, stress cardiomyopathy may be the major cause, based on patients' echocardiographic data. Stress cardiomyopathy has been reported after non-cardiac surgery (including cosmetic surgery) [18] and may be the cause or result of OHCA [19,20]. Most of our patients exhibited moderate-to-severe left ventricular systolic dysfunction (mean left ventricular ejection fraction, 34%±15.53%). Second, pulmonary embolisms that develop during office-based surgery may also cause OHCA [21]; however, we encountered no such cases. Third, propofol may cause cardiac arrest during or soon after plastic surgery. In this study, 20 patients (63%) underwent propofol sedation. Propofol is commonly used for the induction and maintenance of the hypnotic effect of sedation or general anesthesia [22]. It is safe in patients undergoing minor

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procedures but may trigger respiratory and/or cardiac arrest in the absence of careful monitoring and management. Propofol infusion can reduce the respiratory drive, trigger protective airway responses, and weaken the muscular tone of the airway. In addition, a negative inotropic effect and vasodilation caused by propofol infusion may induce cardiac suppression [22]. However, in this study, the effect of propofol on mortality could not be determined, as data on propofol dosing and surgical duration were lacking.

Office-based cosmetic surgery tends to be accompanied solely by pulse oximetry to monitor oxygen saturation; neither an audible alarm nor electrocardiography is employed. Such lack of monitoring may delay the detection of respiratory depression and cardiac arrest, negatively affecting outcomes [23]. Furthermore, cosmetic surgeons may lack both basic and advanced cardiac life support training [24]. In a study of OHCA patients on ECLS, Ha et al. [11] suggested that witnessed arrest, bystander CPR, and successful resuscitation were independent predictors of survival to discharge. Early identification is critical [25]. Careful monitoring of plastic surgery patients, as well as proper performance of immediate CPR if indicated, would improve patient safety.

Our study had some limitations. First, the work was retrospective in nature. In addition, the included number of patients was small because the incidence of OHCA during or after office-based cosmetic surgery is very low. However, our hospital is located near >200 office-based cosmetic surgery clinics, and we thus encounter more patients than do other hospitals. In addition, it was difficult to identify the cause of cardiac arrest because data regarding cardiac arrest timing, surgical duration, and anesthetic dosage were lacking. The small sample size rendered it impossible to define the prognostic factors of mortality in patients for whom ECLS was applied and who experienced serious complications.

In conclusion, patients who developed cardiac arrest at office-based cosmetic surgery clinics experienced poor prognoses, despite being placed on ECLS. Survivors exhibited serious complications, including permanent hypoxic brain damage. Careful patient monitoring, and application of CPR if needed, may be critical in cosmetic surgery clinics.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

ORCID

Seong Soon Kwon: https://orcid.org/0000-0001-6516-3220
Byoung-Won Park: https://orcid.org/0000-0002-7137-9025
Min-Ho Lee: https://orcid.org/0000-0003-0748-7766
Duk Won Bang: https://orcid.org/0000-0002-6691-7546
Min-Su Hyon: https://orcid.org/0000-0002-3274-793X
Won-Ho Chang: https://orcid.org/0000-0002-0234-4478
Hong Chul Oh: https://orcid.org/0000-0003-1338-2397
Young Woo Park: https://orcid.org/0000-0001-7858-178X

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