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

¹Division of Cardiology, Department of Internal Medicine and ²Department 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
A 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 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 refractory 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-
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/m². 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 mean±standard deviation, 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. Variables 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),...
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, 13.33; 95% CI, 1.43–123.99; p=0.023), CPR duration (OR, 1.09; 95% CI, 0.99–1.20; p=0.025), pH (OR, 0.06; 95% CI, 0.00–0.377; p=0.016), APACHE score (OR, 1.16; 95% CI, 1.02–1.32; p=0.022), estimated glomerular filtration rate (eGFR; OR, 0.94; 95% CI, 0.90–0.99; p=0.027), and glucose levels (OR, 1.05; 95% CI, 1.00–1.01; 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, 0.92; 95% CI, 0.86–0.99; p=0.025) (Table 4).

Discussion

We found that patients entering cardiac arrest during or

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*       | 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.

*Time of cardiac arrest was defined as the time of arrival to the emergency room of Soonchunhyang University Seoul Hospital.
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
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

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                  |
| Time interval                                 | 1.042 (0.967–1.122)  | 0.283                  |
| Cardiopulmonary resuscitation duration       | 1.091 (1.011–1.177)  | 0.025                  |
| pH                                            | 0.006 (0.000–0.377)  | 0.016                  |
| 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                  |
| 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                  |
| Glucose                                       | 1.005 (1.000–1.011)  | 0.045                  |
| 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.
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.

**Acknowledgments**

This work was supported by the Soonchunhyang University Research Fund.

**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

**References**

1. Guglin M, Zucker MJ, Bazan VM, et al. Venoarterial ECMO for adults: JACC Scientific Expert Panel. J Am Coll Cardiol 2019;73:698-716.
2. Kim H, Cho YH. Role of extracorporeal cardiopulmonary resuscitation in adults. Acute Crit Care 2020;35:1-9.
3. Paden ML, Conrad SA, Rycus PT, Thiagarajan RR; ELSO Registry. Extracorporeal Life Support Organization Registry report 2012. ASAIO J 2013;59:202-10.
4. Le Guen M, Nicolas-Robin A, Carreira S, et al. Extracorporeal life support following out-of-hospital refractory cardiac arrest. Crit Care 2011;15:R29.
5. Lan C, Tsai PR, Chen YS, Ko WJ. Prognostic factors for adult patients receiving extracorporeal membrane oxygenation as mechanical circulatory support: a 14-year experience at a medical center. Artif Organs 2010;34:E59-64.
6. Goswami S, Brady JE, Jordan DA, Li G. Intraoperative cardiac arrests in adults undergoing noncardiac surgery: incidence, risk factors, and survival outcome. Anesthesiology 2012;117:1018-26.
7. Keyes GR, Singer R, Iverson RE, et al. Mortality in outpatient surgery. Plast Reconstr Surg 2008;122:245-50.
8. Seo WY, Lee KS. The spatial characteristics of clinic distribution by specialty subject. J Econ Geogr Soc Korea 2007;10:153-66.
9. Park BW, Seo DC, Moon IK, et al. Pulse pressure as a prognostic marker in patients receiving extracorporeal life support. Resuscitation 2013;84:1404-8.
10. Park SB, Yang JH, Park TK, et al. Developing a risk prediction model for survival to discharge in cardiac arrest patients who undergo extracorporeal membrane oxygenation. Int J Cardiol 2014;177:1031-5.
11. Ha TS, Yang JH, Cho YH, et al. Clinical outcomes after rescue extracorporeal cardiopulmonary resuscitation for out-of-hospital cardiac arrest. Emerg Med J 2017;34:107-111.
12. Johnson NJ, Acker M, Hsu CH, et al. Extracorporeal life support as rescue strategy for out-of-hospital and emergency department cardiac arrest. Resuscitation 2014;85:1527-32.
13. An JX, Zhang LM, Sullivan EA, Guo QL, Williams JP. Intraoperative cardiac arrest during anesthesia: a retrospective study of 218,274 anesthetics undergoing non-cardiac surgery. Chin Med J 2011;124:227-32.
14. Ramachandran SK, Mhyre J, Kheterpal S, et al. Predictors of survival from perioperative cardiopulmonary arrests: a retrospective analysis of 2,524 events from the Get with the Guidelines-Resuscitation registry. Anesthesiology 2013;119:1322-39.
15. Bitar G, Mullis W, Jacobs W, et al. Safety and efficacy of office-based surgery with monitored anesthesia care/sedation in 4778 consecutive plastic surgery procedures. Plast Reconstr Surg 2003;111:150-6.
16. Starling J 3rd, Thosani MK, Coldiron BM. Determining the safety of office-based surgery: what 10 years of Florida data and 6 years of Alabama data reveal. Dermatol Surg 2012;38:171-7.
17. Heidekrueger PI, Juran S, Ehrl D, Aung T, Tanna N, Broer PN. Global aesthetic surgery statistics: a closer look. J Plast Surg Hand Surg 2017;51:270-4.
18. Glamore M, Wolf C, Boolbol J, Kelly M. Broken heart syndrome: a risk of teenage rhinoplasty. Aesthet Surg J 2012;32:58-60.
19. Bahlmann E, Krause K, Harle T, van der Schalk H, Kuck KH. Cardiac arrest and successful resuscitation in a patient with Tako-Tsubo cardiomyopathy. Int J Cardiol 2008;130:e4-6.
20. Kurisu S, Inoue I, Kawagoe T, et al. Tako-tsubo cardiomyopathy after successful resuscitation of out-of-hospital cardiac arrest. J Cardiovasc Med (Hagerstown) 2010;11:465-8.
21. Phillips BT, Wang ED, Rodman AJ, et al. Anesthesia duration as a marker for surgical complications in office-based plastic surgery. Ann Plast Surg 2012;69:408-11.
22. Sahinovic MM, Struys MM, Absalom AR. Clinical pharmacokinetics and pharmacodynamics of propofol. Clin Pharmacokinet 2018;57:1539-58.
23. Bhananker SM, Posner KL, Cheney FW, Caplan RA, Lee LA, Dominno KB. Injury and liability associated with monitored anesthesia care: a closed claims analysis. Anesthesiology 2006;104:228-34.
24. Rohrich RJ, Parker TH 3rd, Broughton G 2nd, Garza R, Leblanc D. The importance of advanced cardiac life support certification in office-based surgery. Plast Reconstr Surg 2008;121:93e-101e.
25. Dami F, Heymann E, Pasquier M, Fuchs V, Carron PN, Hugli O. Time to identify cardiac arrest and provide dispatch-assisted cardio-pulmonary resuscitation in a criteria-based dispatch system. Resuscitation 2015;97:27-33.