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BỆNH VIỆN BỎNG QUỐC GIA LÊ HỮU TRÁC
Le Huu Trac National Burn Hospital

HỘI BỎNG VIỆT NAM
Vietnam Burn Association

HỘI Y HỌC KHẨN CẤP VÀ THẢM HỌA VIỆT NAM
Vietnam Association of Disaster and Emergency Medicine

6

2023

THỂ LỆ GỬI BÀI ĐĂNG
TẠP CHÍ Y HỌC THẨM HỌA VÀ BỎNG

I. MỤC ĐÍCH VÀ PHẠM VI CỦA TẠP CHÍ

Tạp chí Y học Thẩm họa và Bỏng xuất bản 6 kỳ/năm (trong đó có 01 số xuất bản bằng ngôn ngữ tiếng Anh), một số khoảng 70 trang, đăng tải các chuyên đề:

1. Chuyên đề y học thẩm họa.

2. Chuyên đề phòng, điều trị bỏng và nghiên cứu khoa học về bỏng và phẫu thuật tạo hình, thẩm mỹ.

3. Các tài liệu lược dịch về bỏng - Phẫu thuật tạo hình, thẩm mỹ và thẩm họa.

4. Tin tức vấn đề và sự kiện y tế trong nước và quốc tế.

***Mục đích:** Trao đổi thông tin nghiên cứu khoa học về bỏng và phẫu thuật tạo hình, thẩm mỹ trong mạng lưới điều trị bỏng toàn quốc; nâng cao nhận thức về phòng tránh thẩm họa, bỏng cho cộng đồng.*

***Phạm vi phát hành:** Toàn quốc*

II. MỘT SỐ YÊU CẦU VỀ BÀI ĐĂNG CÔNG TRÌNH NGHIÊN CỨU KHOA HỌC

1. Bài gửi đăng công trình nghiên cứu khoa học chưa đăng ở bất kỳ tạp chí quốc gia nào.

2. Các thuật ngữ thống nhất theo Từ điển Bách khoa Việt Nam.

3. Bài gửi đăng phải đánh máy bằng tiếng Việt Nam (thống nhất dùng font - Unicode cả bài), rõ ràng, cách dòng, một bài không quá 7 trang khổ A4, kể cả bảng biểu, ảnh, và tài liệu tham khảo. Các danh từ tiếng Việt nếu dịch từ tiếng nước ngoài viết kèm theo tiếng nước ngoài. Các chữ viết tắt phải có chú thích các từ gốc của các chữ viết tắt.

4. Trình tự các mục trong bài:

a. Đầu đề (ngắn nhưng đầy đủ, dễ hiểu và đầu đề phải dịch ra tiếng Anh)

b. Họ và tên tác giả (không ghi học hàm, học vị và chức danh)

c. Địa chỉ cơ quan đang công tác hoặc Email (nếu cần thiết)

*d. Nội dung: **Tóm tắt:** tiếng Việt Nam và tiếng Anh hoặc tiếng Pháp (tối đa 150 từ). Ghi từ khoá tiếng Việt và tiếng Anh). **Đặt vấn đề** bao gồm cả phần mục đích nghiên cứu. **Đối tượng và phương pháp nghiên cứu, kết quả, bàn luận, kết luận*** (chỉ sử dụng những biểu, bảng, ảnh cần thiết và phải có chú thích rõ yêu cầu in vào đoạn nào trong bài).

*e. **Tài liệu tham khảo** nên chọn lọc (không quá 10 tài liệu). Xếp theo thứ tự vần A, B, C... Cần nêu đủ theo thứ tự: tên tác giả, tên bài báo, tập san báo, số, năm, hoặc quyển (tập) nơi xuất bản, trang đối với cả phần tài liệu tham khảo tiếng Việt, tiếng Anh, tiếng Pháp. Phần tài liệu tham khảo đặt ở cuối bài báo.*

5. Mỗi tác giả đứng tên đầu của bài báo chỉ được đăng một bài trong mỗi phần của một số.

6. Bài được đăng đều được trả tiền nhuận bút theo giá thoả thuận.

7. Không trả lại bản thảo khi không được đăng.

III. ĐỐI VỚI CÁC BÀI TỔNG QUAN THÔNG TIN VÀ BÀI DỊCH

Đối với bài tổng quan cần có đầy đủ các tài liệu tham khảo và nguồn số liệu đã được trích dẫn trong bài. Tác giả bài tổng quan được ghi rõ chức danh, học hàm, học vị, chuyên ngành, cơ quan hoặc hội đồng chuyên khoa ở phần ghi chú cuối trang đầu của bài tổng quan. Bài tổng quan cũng phải đánh máy trên một mặt giấy khổ A4 và không dài quá 7 trang kể cả bảng biểu và tài liệu tham khảo.

Các thông tin và bài dịch cần ghi rõ xuất xứ của nguồn dữ liệu và của thông tin hoặc bài dịch. Đối với bài dịch cần chụp (photo) toàn văn bài báo tiếng nước ngoài gửi kèm theo với bản dịch.

Người viết bài hoàn toàn chịu trách nhiệm trước Ban biên tập, công luận và những Qui định liên quan đến Luật Báo chí.

Rất mong sự cộng tác, đóng góp ý kiến và phê bình của các bạn!

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Giấy phép xuất bản số 231/GP-BTTTT Bộ Thông tin Truyền thông cấp ngày 06/7/2023

In 500 cuốn tại NXB Nông nghiệp

in xong và nộp lưu chiểu tháng 10/2023

MỤC LỤC

NGHIÊN CỨU KHOA HỌC

Ảnh bìa 1: Ban Gám đốc Bệnh viện cùng các thầy cô Bộ môn Bỏng và Y học thảm hoạ Khai giảng Lớp Đào tạo kiến thức và thực hành cơ bản chuyên khoa Bỏng (6/2023).

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CHARACTERISTICS AND FACTORS AFFECTING THE OUTCOMES OF MASSIVE BURN PAEDIATRIC PATIENTS

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SUMMARY

This study investigated characteristics and factors affecting the outcome of massive burns in children. A retrospective study was conducted on 288 pediatric burn patients (=<16 years old) with burn extent ≥ 30% of total burn surface area (TBSA) admitted to the Le Huu Trac National Burns Hospital from 1/1/2018 to 31/12/ 2022. Patients were divided into two groups of survival and death comparing demographic characteristics, burn features, and outcome. The results showed that most patients were under 6 years old (79.51%), boys (64.58%), due to scald (76.69%). Inhalation injury accounted for 6.25% and the overall mortality rate was 6.94%. There was no remarkable difference between survival and death groups in terms of age, gender, and admission time (p > 0.05). Meanwhile, the death group had significantly greater burn extent, deep burn area as well as the rate of inhalation injury than the survival group (p < 0.01). The most fatal causal agent was flame as compared to scald and other agents (18.75%; p < 0.01). Multivariate analysis showed that the increased deep burn area and the presence of inhalation injury were independent risk factors for mortality with AUC = 0.82; sensitivity: 80%; specificity: 91.42% in the case of combining both variates.

Keywords: *Massive burns, pediatric, outcomes*

1. INTRODUCTION

Burns in children account for a large proportion of burn patients in the community as well as those treated at medical facilities. Along with advances in fluid resuscitation, necrosis excision, early coverage with skin substitutes, infectious control, and comprehensive care the complication and mortality rate have been improved in burn patients including pediatric burns [1], [2]. However, the treatment of massive burn patients remains a global challenge due to the lack of autologous skin and the great risk of complications. In children, a massive burn was defined as a burn extent > 30% of the total body surface area (TBSA) [3].

Due to anatomical and physiological

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characteristics, the responses and progression of pediatric burn patients were different from those of adult burn patients. According to reports, in developed countries, the mortality rate in massive burn children patients currently ranges from 5% to 25% [3], [4], [5]. There were very few reports on this topic in developing countries, including Vietnam. In this study, we analyzed the characteristics and factors predicting mortality in massive burn pediatric patients treated at the National Burn Hospital over 5 years (2018 - 2022).

2. PATIENTS AND METHODS

A retrospective study was conducted on 288 burn pediatric patients (0 - 16 years old), burn extent ≥ 30% of TBSA admitted to the National Burns Hospital from 1/1/2018 to 31/12/2022. Patients were divided into two groups of survival and death comparing demographic characteristics, burn features, and outcome. Bivariate and then multivariate analyses were analyzed to identify factors that independently affect mortality. Area under the curve (AUC), sensitivity, and specificity were determined by ROC test:

+ AUC > 0,9: Very good
+ AUC = 0,8 ÷ 0,9: Good
+ AUC = 0,7 ÷ 0,8: Quite good
+ AUC = 0,6 ÷ 0,7: Medium
+ AUC < 0,6: Low

The optimal cutoff point was determined by the Youden index:

J = max(Se+Sp -1).

In which: J: Optimal cutoff point; Se: Sensitivity; Sp: Specificity

Stata 14.0 software was used and p value < 0.05 was considered a statistically significant level.

3. RESULT

Table 3.1. Patient's characteristics

Parameter	Sub-group	Total (n = 288)	Survival (n = 268)	Death (n = 20)	p
Age, n (%)	< 6	229 (79.51)	213 (79.48)	16 (80)	0,97
	6 - 16	59 (20.49)	55 (20.52)	4 (20)	
	Median	3 (2-6)	3 (2 - 6)	3.5 (2 - 5.5)	0.76
Gender, n (%)	Male	186 (64.58)	177 (95.16)	9 (4.84)	0.06
	Female	102 (35.42)	91 (89.22)	11 (10.78)	
Admission time n (%)	< 24h	230 (79.86)	217 (94.35)	13 (5.65)	0.09
	≥ 24h	58 (20.14)	51 (87.93)	7 (12.07)	
Causal agents, n (%)	Scald	218 (75.69)	211 (96.79)	7 (3.21)	0.001
	Flame	64 (22.22)	52 (81.25)	12 (18.75)	
	Others	6 (2.1)	5 (83.3)	1 (16.7)	
Burn extent, % TBSA		35 (30 - 45)	35 (30 - 41)	59 (36 - 62)	0.001
Deep burn area, % TBSA		6 (0 - 15)	6 (0 - 13)	30 (10 - 40)	0.001
Inhalation injury, n (%)		18 (6.25)	8 (44.44)	10 (55.56)	0.001

TBSA: Total body surface area

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In 5 years (1/2018 - 12/2022), there were 288 massive burn pediatric patients treated at National Burn Hospital, of which 20 patients died, accounting for 6.94%. Most patients were < 6 years old (79.51%), boys (64.58%), and hospitalized before 24 hours after burn (79.86%). The common casual agent was scald (75.69%) and inhalation injury was recorded in 6.25%.

There was no significant difference between the two groups in terms of age, gender, and admission time after burn injury (p > 0.05). However, the death group had significantly greater burn extent, deep burn area as well as the rate of inhalation injury than the survival group (p < 0.01). The most fatal causal agent was flame as compared to scald and other agents (18.75%; p < 0.01).

Table 3.2. Multivariate analysis of mortality

Parameter	Coef. (95% CI)	OR (95% CI)	p
Flame burn	0.63 (-2.52 ÷ 1.26)	0.53 (0.08 ÷ 3.54)	0.52
Burn extent	0.02 (-0.02 ÷ 0.07)	1.02 (0,98 ÷ 1,07)	0.29
Deep burn area	0.08 (0.03 ÷ 0.13)	1.08 (1.03 ÷ 1.14)	0.002
Inhalation injury	3.10 (1.07 ÷ 5.14)	22.3 (2.9 ÷ 170.6)	0.003
_cons.	-5.15 (-7.15 ÷ -3.16)	0.006 (0.001 ÷ 0.043)	0.000
OR: Odds ratio; Coef. : Coefficient; CI: Confidence interval; cons.: Constant			

Multivariate analysis showed that the deep burn area (OR: 1.07) and the presence of inhalation injury (OR: 9.07) were independent factors predicting mortality (p < 0.01). The presence of inhalation injury increases the risk of mortality by 22.3 times, and each 1% increase in deep burn area increases the risk of death by 1.08 times.

The logit equation of deep burn area (DBA) and inhalation injury (IH) was obtained as follows: Logit (mortality) = 0.08*DBA + 2.68*IH - 4.31.

Table 3.3. Mortality prognostic value of deep burn area and inhalation injury

Parameter	AUC (95%CI)	Cutoff	Sensitivity (%)	Specificity (%)
DBA	0,77 (0,61 - 0,93)	20	75	88.06
IH	0,74 (0,62 - 0,85)	Có	50	97.01
DBA+IH	0,82 (0,67 - 0,96)		80	91,42
DBA: Deep burn area; IH: Inhalation injury				

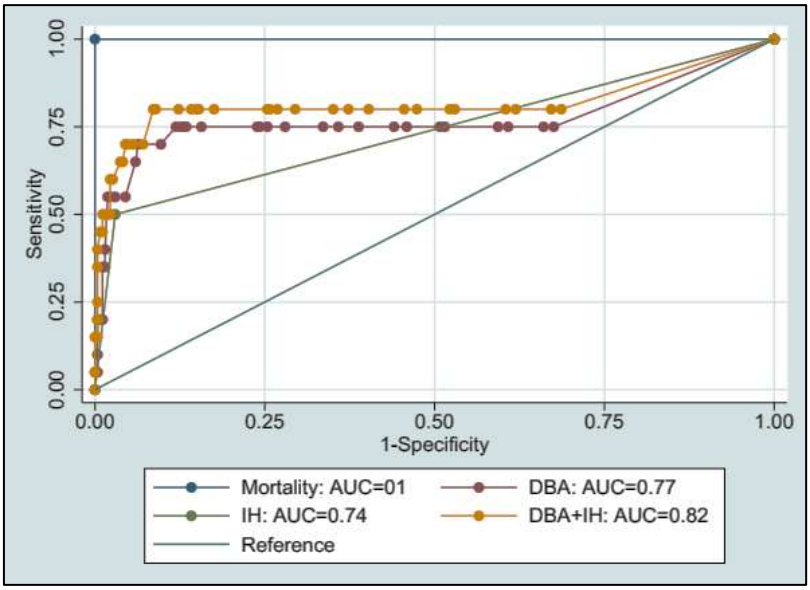

Figure 3.1. ROC curve showing the mortality prognostic value of DBA, IH, DBA+IH

The prognostic value of mortality in massive burn pediatric patients of deep burn area and the presence of inhalation injury were quite good (AUC = 0.77 and AUC = 0.74). When combining these two factors, the results: AUC = 0.82; 95%CI: 0.67-0.96; sensitivity: 80%; specificity: 91.42%.

4. DISCUSSION

Regarding the characteristics of massive burn pediatric patients, there were differences in age and gender ratios. In our study, children under 6 years old account for the majority of hospitalizations (79.51%), mainly boys (64.58% vs. 35.42%). This was similar to other reports around the world. Lee et al (2016) analyzed 2273 pediatric burn patients hospitalized from 1995 - 2013 in the United States and showed that the majority of children hospitalized were aged 0 - 6 years old (73.2%), mainly males (61.6 %) [6]. A multicenter analysis in China of 486 pediatric burn cases reported that 58.64% were male [3].

Regarding the causal agent, reports around the world showed that the main causal agent of burns were scald [3], [6], [7]. Our research results were also consistent with the above statement with 75.69% of burn patients suffering scalds. Regarding inhalation injury, Cheng and colleagues (2019) studied 486 massive burn pediatric patients in 106 burn centers in China and found that the rate of inhalation injury was 8.85% [3]. The rate of inhalation injury in our study was 6.25%. The mortality rate in our study was 6.97%; higher than other studies [3], [5]. This shows that we still have a lot of work to do to improve the quality of treatment for massive burn paediatric patients.

Multiple studies have confirmed that increasing age, burn extent, deep burn area, and the presence of inhalation injury were independent predictors of mortality [5], [8], [9], [10]. Research by Martens and colleagues (2023) on 69 massive burn pediatric patients hospitalized for 10 years at the Children's Hospital of Northern California

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found that the presence of inhalation injury was an independent predictor of mortality (OR = 3, 4; p = 0.04) [5].

Another report in Iran (2015) also showed similar results, inhalation injury was one of the risk factors for mortality in pediatric burn patients (OR: 8.75; p = 0.009) [11]. Chalya and colleagues (2011) analyzed 342 pediatric burn patients hospitalized at Bugando Medical Center (Tanzania) from January 2008 to December 2010 and found the mortality rate was 11.7%. In addition, burn extent (OR = 2.54; p = 0.012), inhalation injury (OR = 6.43; p = 0.011), along sepsis (OR = 6.86; p = 0.000) were independently related factors to the mortality [12].

In our study, multivariate regression analysis for mortality showed that an increased thickness of the burn area (OR = 1.07; 95%CI: 1.02-1.11; p = 0.002) and presence of inhalation injury (OR = 9.07; 95% CI: 2.13 - 38.59; p = 0.003) were independent factors predicting mortality. The presence of inhalation injury increases the risk of death by 22.3 times, each 1% increase in deep burn area increases the risk of death by 1.08 times. When combining these two factors, the results: were AUC = 0.82, 95%CI: 0.67 - 0.96, sensitivity: 80%, specificity: 91.42%.

5. CONCLUSION

Burn deep area and the presence of inhalation injury were independently associated with mortality in massive burn pediatric patients. When combining the thickness of the deep burn area and inhalation injury, the predictive value of mortality was good.

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EVALUATING THE INTRAOPERATIVE CHANGES IN SEVERAL HEMODYNAMIC PARAMETERS USING THE USCOM METHOD IN SEVERE BURN PATIENTS UNDERGOING BURN NECROTOMY, SKIN GRAFTING

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ABSTRACT

***Objective**: To evaluate the intraoperative changes in some hemodynamic parameters by the USCOM method in severe burn patients undergoing burn necrotomy, and skin grafting.*

***Subjects and methods:** 30 severe burn patients, aged 16 - 60 years old, treated at the ICU, National Burn Hospital, were scheduled for necrosis and skin grafting from May 2023 to December 2023. Cross-sectional, clinical descriptive study.*

***Results:** CO and CI values at all study times were within normal limits (3.5-8 l/min and 2.4-4.2 l/min/m^2). CO and CI were highest at the time of pre-medication (6.93 and 4.24) and lowest at the time of skin grafting (5.87 and 3.61). SVR values at all times were within normal limits (800 - 1600 d.s.cm-5). SVR was highest at the time the patient was awake (1278.33) and lowest at the time immediately after induction of anesthesia (976.93). SVRI values 3 times after induction of anesthesia, before necrotomy, and at the time of necrotomy were lower than normal values (1800 - 3200 d.s.cm-5.m^2). SVI at the remaining time points was within normal limits. SV values at all times were within normal ranges (50-110 cm^3). SVI values at most times were smaller than normal values (35 - 65 ml/m^2), except for at the time of necrotomy (35.03). SVV values at all times were higher than normal (< 20%).*

***Conclusion:** Stroke volume variation (SVV) parameters at all study times were higher than normal values corresponding to the age range. The stroke volume index parameter SVI at most times was lower than the normal value, and SVRI at all times was not higher than the normal value. However, the parameters cardiac output (CO), cardiac index (CI), stroke volume (SV), and systemic vascular resistance (SVR) were all within the range of normal values corresponding to the age range at the research time points.*

***Keywords**: USCOM, anesthesia, necrotomy, skin grafting, burn*

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1. INTRODUCTION

Intraoperative blood loss can bring about hemodynamic disorders and affect the function of organs, especially the heart, kidney, and brain; acid-base imbalance; hypothermia; coagulation disorder; and even death. Burn necrotomy and skin grafting for treating severe burn patients usually result in much blood loss. According to a statistic, for every 1% of burn necrosis removed, the amount of blood loss is 6.4 ± 5% of the total blood in the body [1]. Therefore, intraoperative hemodynamic monitoring in burn necrotomy and skin grafting in severe burn patients is essential in order to early detect and timely correct hemodynamic disorders.

In recent years, the Ultrasound Cardiac Output Monitoring (USCOM) method has allowed for the monitoring of hemodynamics in a non-invasive manner. Studies have shown that the USCOM method has the same reliability as invasive methods such as PiCCO in monitoring hemodynamic parameters such as cardiac index (CI), stroke volume index (SVI), stroke volume variation (SVV), and systemic vascular resistance index (SVRI) [2]. This method has been applied to monitoring hemodynamic parameters in severe burn patients in the stages of burn shock and septic shock [3]. However, this method has not been systemically applied for hemodynamic monitoring in burn necrotomy and skin grafting surgery in severe burn patients. Consequently, we conducted this study in order to evaluate the changes in some hemodynamic parameters by using USCOM in burn necrotomy and skin grafting surgery in severe burn patients.

2. SUBJECTS AND METHODS

2.1. Subjects

* Subjects: 30 severe burn patients, treated in the ICU, Le Huu Trac National Burn Hospital, from May 2023 to December 2023.

* Inclusion criteria: Aged 16 - 60 years old, burn area 30 - 60%, indicated for burn necrotomy: 5 - 15% total body surface area (TBSA), ASA II, III.

* Exclusion criteria: Patients with concomitant traumas, myocardial diseases (valve diseases, heart failure with NIHA III, IV, arrhythmia).

2.2 Methods

The clinical descriptive cross-sectional study.

2.2.1. Medications and materials

Midazolam ampoule 5mg/ml (Rotexmedica - Germany), Ketamine vial 500mg/10ml (Rotexmidica- Germany), Propofol ampoule 200mg/20ml (Fresenius Kabi-Austria), Fentanyl ampoule 500mcg/10ml (Rotexmidica - Germany). Medications for repiratory, circulatory resuscitation, and fluids.

USCOM machine version 2 (USCOM company, 2009, Australia) with Dopper probe 2.2MHz, Life Scope Nihon Kohden (Japan), able to monitor heart rate, ECG, invasive blood pressure, and SpO_2.

2.2.2. Procedure

- At the ICU, Le Huu Trac National Burn Hospital, the patient was examined

one day before surgery and guided for preoperative fasting.

- At the Operating Room

- The patients were monitored for heart rate, invasive blood pressure, respiratory rate, and SpO_2.

- Given an IV infusion with Ringerlactat of 10ml/kg

- Anesthesia procedure

+ Premedication: Midazolam 0.05mg/kg

+ Induction: Ketamin 1mg/kg, Fentanyl 3μg/kg, and Propofol 3mg/kg. When the patient lost consciousness, the mouth muscle relaxed, the LMA was inserted.

+ Maintenance: Using volume control ventilation (VCV) mode with Vt = 8ml/kg ideal body weight, respiratory rate 14-16 breaths/min, and an I: E ratio of 1:2 to maintain an $EtCO_2$ of 30 - 40mmHg. Propofol 1mg/kg/h was infused via a syringe pump; the dose of 0.2 mg/kg/h propofol was adjusted each time and an additional dose of Fentanyl 1 - 2μg/kg/time was given based on the patient's PRST (systolic blood pressure, heart rate, sweating, tear) score.

- Vital signs were monitored every 5 minutes until the surgery was completed.

- At the Recovery Area.

- The LMA was removed when the patient met the criteria.

- The patient was transferred to the ward when the Aldret score was ≥ 9. Postoperative multimodal analgesia based on the ICU's procedure.

2.2.3. Collected parameters

- Patient demographics: Age, gender, height, weight, necrotomy area, skin grafting area.

- Medication dosage of midazolam, ketamin, propofol, and fentanyl; volume of fluids; blood given intraoperatively.

- Some hemodynamic parameters measured by USCOM: Cardiac output (CO), cardiac index (CI), stroke volume (SV), stroke volume index (SVI), stroke volume variation (SVV), systemic vascular resistance, and systemic vascular resistance index (SVRI)

2.2.4. Study time points

Data was collected at 7 - time points: T_0 (right after premedication), T_1 (right after induction), T_2 (before necrotomy), T_3 (right at necrotomy), T_4 (necrotomy completed), T_5 (skin grafting completed), and T_6 (patient awake).

2.2.5. Data analysis

The Statistical Package for Social Science 22.0 (SPSS 22.0) software was used for data analysis. Data was expressed as either mean or standard deviation ($\bar{X}$ ± SD) or numbers and percentages.

2.3. Research ethics

This study was approved by the Medical Research Ethics Committee of the Military Medical University according to Decision $N_{0.}$ 42/2023/CNChT-HĐĐĐ dated June 16, 2023.

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3. RESULTS

3.1. Patient's characteristics

Table 3.1. Patient's demographics

Parameters		Min - Max	$\bar{X} \pm SD$
Age (year)		18 - 59	38.16 ± 14.15
Gender (n, %)	Male	25 (83.33%)	
	Female	5 (16.67%)	
Weight (kg)		47 - 78	61.16 ± 8.64
Height (cm)		155 - 180	166 ± 7.84
Necrotomy area (%)		5 - 15	9.00 ± 3.05
Skin grafting area (%)		5 - 15	9.06 ± 2.97
Surgery duration (min)		30 - 85	56.37 ± 12.38
Anesthesia duration (min)		55 - 110	81.31 ± 15.95
Midazolam (mg)		2.5 - 4	3.02 ± 0.45
Ketamin (mg)		50 - 80	60.63 ± 9.28
Propofol (mg)		410 - 1000	620.33 ± 147.23
Fentanyl (µg)		150 - 500	345.66 ± 78.19
Amount of fluids intraoperatively administered (ml)		500 - 1000	700.00 ± 222.05
Amount of blood intraoperatively transfused (ml)		0 - 500	333.33 ± 75.80

Comments: The mean age of the patients was 38 years old. The majority of patients were male (83.33%). The necrotomy area and the skin grafting area were almost equal, and the surgery duration was about 1 hour. The amount of fluid and blood administered intraoperatively was about 333ml and 700ml, respectively. The amount of Midazolam, Ketamin, Propofol, and Fentanyl administered intraoperatively was about 3mg, 60mg, 620mg, and 345µg, respectively.

3.2. Changes in intraoperatively hemodynamic parameters

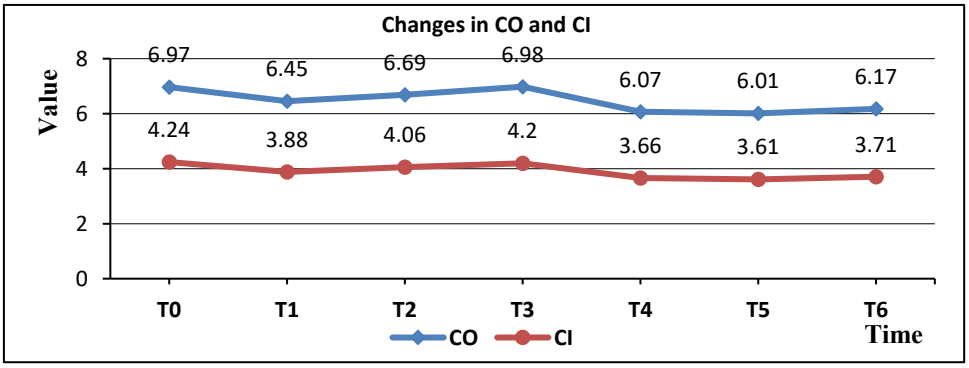

Figure 3.1. Changes in CO and CI at time points

Comments: CO and CI values at all time points were in a normal range (3.5 - 8l/min and 2.4 - 4.2 l/min/m^2). The CO and CI values were highest at the time of premedication (6.93 and 4.24) and lowest at the time of skin grafting (5.87 and 3.61).

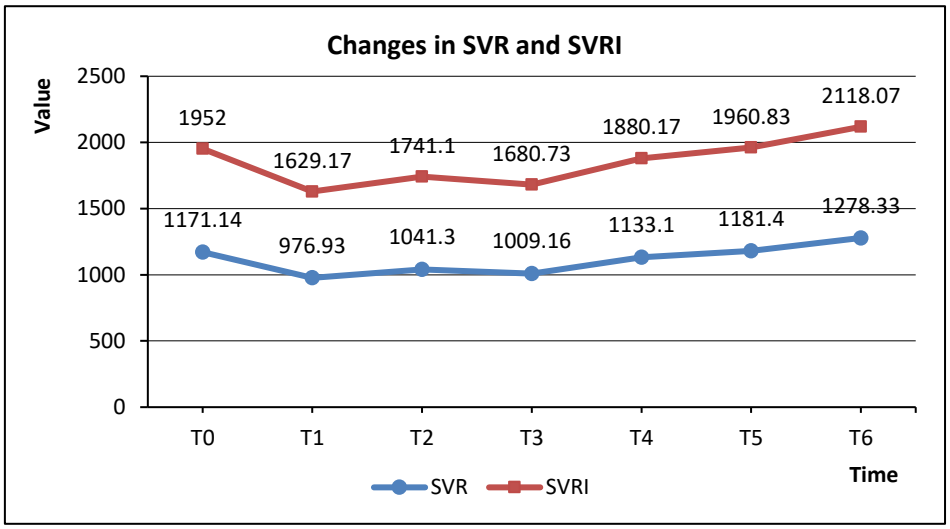

Figure 3.2. Changes in SVR and SVRI at time points

Comments: SVR values at all time points were in a normal range (800 - 1600 d.s.cm^{-5}). SVR was highest at T6 (1278.33) and lowest at T1 (976,93). SVRI at T1, T2, and T3 was lower than the normal value (1800 - 3200 d.s.$cm^{-5}.m^2$). SVRI at the remaining time points was in the normal range.

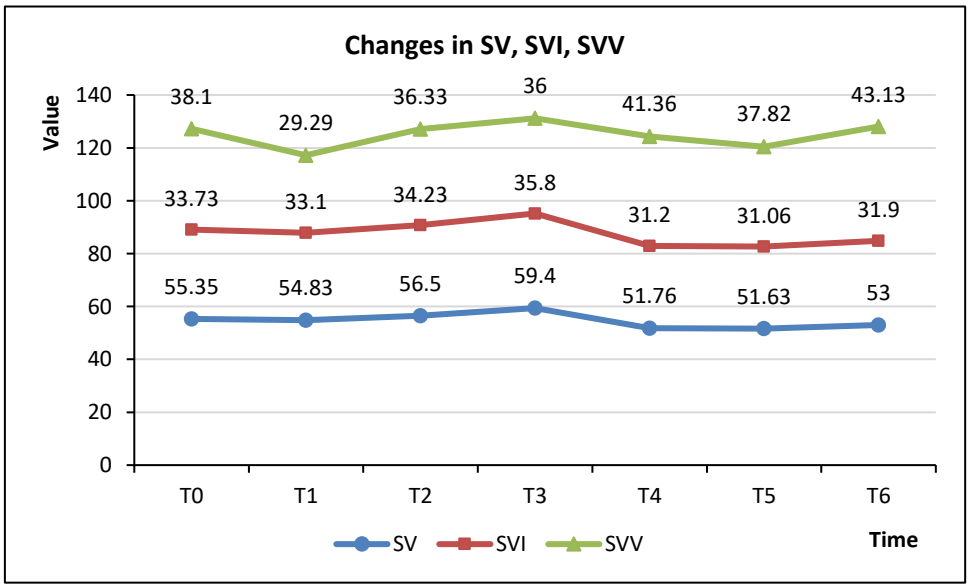

Figure 3.3. Changes in SV, SVI, SVV at time points

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Comments: SV values at all time points were in the normal range (50 - 110cm^3). SVI values at almost all time points were lower than the normal range (35 - 65ml/m^2), except for T3 (35.8). SVV values at all time points were greater than the normal value (< 20%).

4. DISCUSSION

Patients in the study had a mean age of 38 years; the majority were male, with height and weight corresponding to Vietnamese physiological constants (Table 3.1).

Cardiac activity is expressed by cardiac output (CO), which is the volume that the heart pumps out on average per minute and is the result of the coordinated impact of four factors: preload, myocardial contractility, afterload, and heart rate. CO was calculated as stroke volume multiplied by heart rate [3].

CI is calculated as cardiac output divided by the total body skin area. This index does not depend on the patient's body shape or weight, so it is easy to compare in clinical practice [4].

Low CO and CI are due to low SV, low HR, or both, and vice versa. CO is also valuable in assessing total tissue oxygen delivery, as changes in CO determine the amount of oxygen delivered to the tissues. Low or insufficient CO will lead to tissue hypoxia, cellular hypoxia, and irreversible multiorgan dysfunction [3].

In our study, patients had an average age of 38 years (18 - 59), CO values ranged from 3.5 to 8.0 l/min and CI ranged from 2.8 to 4.2 l/min/m^2. According to the research results in Figure 3.1, we found that CO and CI values at the time of the study were within the normal range.

The CO value in our study was consistent with the CO value at time points in the study of Nguyen Quoc Kinh and colleagues (2016), when these authors evaluated hemodynamic changes measured by USCOM in patients undergoing trauma surgery who were administered crystalloid and colloid fluid before spinal anesthesia [5].

Author Phung Van Dung and colleagues (2017), using USCOM to monitor and evaluate hemodynamics in patients with severe sepsis and septic shock, found that the mean CI value was at a normal level in both groups. In the severe infection group, it was 3.51 ± 1.60 ml/min/m^2, and in the septic shock group, it was 3.47 ± 1.50 ml/min/m^2 [6]. CO and CI values were within normal limits, showing that these hemodynamic parameters in severe burn patients were not affected during the induction and maintenance stages of anesthesia.

Stroke volume (SV) is the volume of blood pumped out of the heart's ventricles with each beat. And can apply to both ventricles of the heart, but usually refers to the left ventricle. This parameter is an important determinant of cardiac output because cardiac output is the product of ejection volume and heart rate. Stroke volume decreases under certain conditions, and in pathological conditions, SV is related to cardiac function. Stroke Volume Index (SVI) is the volume of blood pumped out of the ventricles with each heartbeat per unit of skin area.

SV and SVI are valuable parameters that assist in preload assessment. Their

value depends on preload, myocardial contractility, and afterload. Low SV and SVI may be due to low preload (fluid deficiency), weak myocardial contractility, or increased afterload. Conversely, high SV and SVI can be due to fluid overload, increased myocardial contractility, reduced afterload, pain, or anxiety.

In our study, patients had an average age of 38 years (18 - 59), normal values of SV were in the range of 50 - 110cm^3, and SVI was in the range of 35 - 65ml/m^2. According to the results in Figure 3.3, SV values at all times were within normal limits. The SV values in our study were lower than the SV values in the study by author Nguyen Quoc Kinh and colleagues (2016), possibly due to the different nature of the surgery (burn necrotomy and skin grafting versus trauma surgery) and different anesthetic methods (anesthesia versus spinal anesthesia) [5]. SVI values at most times were lower than normal values (Figure 3.3). Author Nguyen Thuy Ngan and colleagues (2020), when using USCOM to monitor hemodynamics in patients with septic shock, showed that SVI at the beginning of the study was lower than normal values (32.5 ± 6.8 ml/m^2) [7].

Stroke volume variation (SVV) was used as an index of ventricular filling. When intrathoracic pressure changes with respiration, the amount of venous blood returning to the heart also changes. Increased intrathoracic pressure will reduce blood flow to the heart and reduce ventricular filling, so SV will also decrease. A volume-deficient patient will have a higher SVV than a volume-adequate patient. SVV is not essentially a reflection of the patient's preload but can assist in assessing the effectiveness of fluid therapy. SVV is believed to have significantly higher sensitivity and specificity than traditional circulatory assessment indices such as heart rate, mean arterial blood pressure, and central venous pressure. In clinical practice, SVV has been widely applied to evaluate fluid response as well as support preload assessment in critically ill patients or those undergoing major surgery.

According to the results in Figure 3.3, SVV values at all study times were higher than normal values (< 20%), indicating a preload deficiency during the surgical period. This situation may occur, possibly due to the use of propofol to anesthetize a surgical procedure with excessive blood loss, thereby causing peripheral vasodilation. Our results were similar to the study of Phung Van Dung and colleagues (2017) in patients with severe infection and septic shock, showing the average value of SVV at the time of hospital admission in two groups of severe infection and septic shock was 27.59 ± 14.16% and 25.33 ± 9.45%, respectively. [6].

Systemic vascular resistance (SVR) is the most accurate afterload assessment parameter. SVR is also known as peripheral vascular resistance, and it depends on the structure of the vascular system, the tone of the arterioles, and the viscosity of the blood. According to the results in Figure 3.2, SVR values at all times were within the normal value range (800 - 1600 d.s.cm^{-5}), the lowest was right after the induction of anesthesia, and the highest was when the patient woke up. This result is also consistent with the study of Nguyen Quoc Kinh and colleagues

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(2016), showing that SVR values at the time of the study in the 0.9% NaCl infusion group were all within normal values, with SVV The lowest was 1300.9 d.s.cm^{-5} and the highest was 1450 d.s.cm^{-5} [5].

According to Figure 3.2, SVRI at all times was not higher than the normal value. Our results are also consistent with the study of Phung Van Dung and colleagues (2017), which showed that the average SVRI values in the severe infection group and the septic shock group were 1789.83 ± 788.83 d.s.cm^{-5}.m^2 and 1575.69 ± 917.14 d.s.cm^{-5}.m^2, respectively [6].

5. CONCLUSION

Through studying 30 cases of burn necrosis and skin grafting, we found that the stroke volume variation (SVV) parameter at all study times was higher than the normal value corresponding to the age range. On the contrary, the SVI stroke volume index at most times was lower than the normal value, and the SVRI at those times was not higher than the normal value. However, the parameters cardiac output (CO), cardiac index (CI), stroke volume (SV), and systemic vascular resistance (SVR) were all within the range of normal values corresponding to the age range at the research time points.

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EVALUATION OF THE CHANGES IN SPCO INDEX IN PATIENTS WITH INHALATION INJURY

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ABSTRACT

Objective: *Evaluate the variation of SpCO index with clinical symptoms, medical support pre-hospital, and mortality rate of inhalation injury patients.*

Subjects and methods: *Prospective descriptive study with longitudinal follow-up in inhalation injury patients at the Intensive Care Unit - Le Huu Trac National Burns Hospital from March 2022 to May 2023. 50 patients with inhalation injuries were hospitalized within the first 72 hours. Patients were treated according to the treatment regimen for inhalation injury and CO poisoning. Subclinical and clinical symptoms were recorded and compared. The data was processed using STATA 16.0 software.*

Results: *The average SpCO index upon admission in the study patients was 15.7%. 24 patients admitted to the hospital before 5 hours had an average SpCO index was 8.3 ± 7.6%. 88% of patients were hospitalized within 12 hours of the accident. Medical support pre-hospital: Oxygen supply 63.3%, endotracheal intubation 35% and mechanical ventilation 25%. Respiratory assessment indicators including SpO_2 and average PaO_2 were high and had no statistical difference. Patients with a severe grade of inhalation injury have a high SpCO index upon admission. The mortality rate was high (> 70%) and the SpCO index at admission has no relationship with mortality rate.*

Conclusion: *Patients with CO poisoning were hospitalized early, the SpCO index decreased over time and did not correlate with treatment outcome. Patients with more severe inhalation injuries had a higher SpCO index upon admission. Symptoms are non-specific mortality rate was high, causing confusion and making it difficult to diagnose and predict inhalation injury patients.*

Keywords: *Carbon monoxide poisoning, inhalation injury*

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1. INTRODUCTION

Inhalation injury patients often suffer burns in closed rooms with the main agents being flame burns and accompanying combustion products that can be inhaled during the burn process. In addition to the cause of death due to severe burns, the cause of carbon monoxide poisoning is a factor that aggravates respiratory disorders. During combustion, most materials produce toxic gases, the common being CO and CO_2. CO poisoning is the leading cause of death in fires and accounts for about half of all burn deaths [1].

Toxicity to humans is often overlooked because CO is odorless and tasteless, and its clinical symptoms and signs are nonspecific. CO poisoning would be definitively diagnosed when that index in the blood reaches 10% and above [2].

To measure the CO index in the blood, specialized equipment such as a non-invasive pulse SpCO meter or a separate blood gas kit is not common in Vietnam, definitive diagnosis is still difficult. This greatly affects the treatment attitude, prognosis of medical staff with CO poisoning in general and inhalation injury patients in particular.

2. SUBJECTS AND METHODS

2.1. Subjects

Criteria for Selecting Study Patients

- 50 inhalation injury patients, treated at the Intensive Care Unit - Le Huu Trac National Burns Hospital from March 2022 to May 2023.

- Patients were diagnosed with inhalation injury burns based on bronchoscopy results. Classify the grade of inhalation injury according to Endorf (2007).

- Patients had measured SpCO index with a handheld Masimo Radical -7 meter.

Exclusion criteria: The patient is hospitalized after 72 hours.

2.2. Methods

- Prospective study describing longitudinal follow-up, comparing before and after according to clinical criteria.

- Diagnosis of CO poisoning is still based on measuring COHb concentration, Masimo's Rad-7 meter determines COHb [4].

- Diagnosis of CO poisoning is confirmed when the measured SpCO index is 10% or higher. Monitor SpCO index every 2 hours and clinical symptoms.

- Group 1 is hospitalized patients with a measured SpCO index of 10% or more.

- Group 2 is hospitalized patients with a measured SpCO index below 10%.

2.3. Data processing

- Study data are processed according to medical statistical methods by STATA 16.0 software.

- Data were expressed as either mean and standard deviation ($\bar{X} \pm SD$) or numbers and percentages, the X^2 test was performed for comparing groups.

- P value < 0.05 is considered statistically significant.

3. RESULTS

Table 3.1. Characteristics of study patients

Characteristics	$\bar{X}$ ± SD (n = 50)	Min-Max
Age	37.1 ± 11.9	16 - 65
Total burn surface area (%)	63.5 ± 23.3	1 - 95
Deep burn area (%)	37.3 ± 22.6	0 - 89
Male/Female	42/8 (84%)	

Comments: The study patients had average burn areas of severe burns. The total burn area (TBA) is over 60%, the deep burn area is nearly 40%. The patients are mainly male (84%).

Table 3.2. Characteristics of respiratory index upon admission

Characteristics	Group 1	Group 2	p
	$\bar{X}$ ± SD (n = 20)	$\bar{X}$ ± SD (n = 30)	
pH	7.3 ± 0.11	7.29 ± 0.12	0.33
pO_2	168.1 ± 129.1	147.1 ± 77.4	0.24
Lactate	4.8 ± 3.1	3.9 ± 1.7	0.08
SpO_2	96.3 ± 2.9	97.2 ± 3.2	0.82
SpCO	15.7 ± 4.7	1.2 ± 1.8	

Comments: Inhalation burn patients with CO poisoning had a high average pO_2 index of 168.1mmHg. The pH, pO_2, SpO_2 indices had no difference between the two groups. The lactate index in the CO poisoning group was high but not statistically significant compared to the non-CO poisoning group with p = 0.08.

Table 3.3. Characteristics of pre-hospital treatment and result

Pre-hospital treatment	Group 1 n = 20 (%)	Group 2 n = 30 (%)	p
Oxygen supply	10 (50%)	19 (63.3%)	0.349
Endotracheal intubation	7 (35%)	14 (28%)	0.413
Mechanical ventilation	5 (25%)	12 (24%)	0.273
Results of the treatment			
Survival	5 (25%)	6 (20%)	0.676
Death	15 (75%)	24 (80%)	

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Comments: CO poisoning patients received respiratory support pre-hospital equivalent to non-CO poisoning patients ($p > 0.05$). Mortality was high and had no difference between the two groups ($p > 0.05$).

Table 3.4. SpCO index measured by the time of admission

SpCO index by the time of admission	n (%)	$\bar{X} \pm SD$ (%)	Min-max
0 - 5h	24 (48%)	8.3 ± 7.6	0 - 24
6 - 12h	20 (40%)	6.9 ± 8.7	0 - 27
13 - 24h	3 (6%)	1.3 ± 2.3	0 - 4
> 24h	3 (6%)	2 ± 2.6	0 - 5

Comments: There were 24 patients admitted before 6 hours with an average SpCO index of 8.3%, the highest measured was 24%. Patients with the highest index recorded were 27% hospitalized after 8 hours

Table 3.5. The risk factors for death

Risk factors	p	Hazard-ratio	95% Confidence Interval
Age (age)	0.008	1.035	1.009 - 1.061
Admission time (hour)	0.481	0.984	0.94 - 1.028
Total surface area (%)	< 0.001	1.034	1.016 - 1.053
Deep burn area (%)	< 0.001	1.032	1.016 - 1.047
SpCO index admission (%)	0.736	0.993	0.961 - 1.133

Comments: The risk factors for death by age and burn area are statistically significant ($p < 0.05$). SpCO index at admission has no relationship with mortality rate.

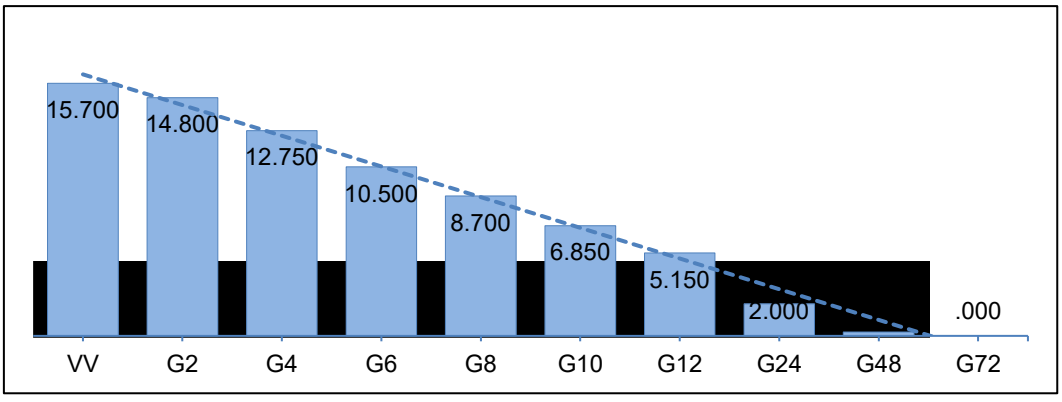

Figure 3.1. Evolution over time

Comments: The SpCO index gradually decreases over time of hospitalization. After 6 hours, the SpCO index decreased to less than 10% and no patient was detected with CO after 72 hours.

Table 3.6. SpCO index according to a grade of inhalation injury

Classification according to Endorf	n	%	SpCO index (%)	
			$\bar{X}$ ± SD	p
Grade 1	15	30	3.3 ± 5.6	$p^{1-2} = 0.06$
Grade 2	27	54	6.9 ± 8.2	$p^{2-3} = 0.03$
Grade 3	7	14	13.3 ± 6.3	$p^{1-3} < 0.001$
Grade 4	1	2	19	

Comments: Patients with a more severe grade of inhalation injury have an average higher SpCO index. One patient with a 4th-grade inhalation injury had a SpCO index of 19%.

4. DISCUSSION

4.1. Characteristics of study patients

Inhalation injury patients are at high risk of CO poisoning. According to 2021 global statistics, the global mortality rate from CO poisoning is 0.366 per 100,000; with 28,900 deaths and 1,18 million cases across all ages. Nearly 70% of deaths occur in men, and the 50 - 54 age group has the highest number of deaths [5].

The study patients were a group of adult patients, on average of working age (mean age 37.1 ± 11.9). It can be explained by the fact that burn injuries are mainly due to work and daily life accidents. The TBSA (total body surface area) is very large, on average 63.5 ± 23.3%, but is unevenly distributed. The smallest case had 1%. Similar to the area of deep burns, an average of 37.3 ± 22.6% of the TBSA and there were patients in the study who did not have deep burn lesions.

The average TBSA is similar to the results of author Nguyen Nhu Lam and colleagues (2019) in their study on inhalation injury [6]. Regarding the characteristics of the group of inhalation injury patients with CO poisoning (group 1), there were no differences in age, deep burn area and Apache II score upon admission compared to the group inhalation injury patients without CO poisoning (group 2). There was a difference in the overall burn area: Group 2 had a statistically significantly larger area than Group 1 (p = 0.03). This may indicate that a large burn area is not a factor related to CO poisoning. The study patients were severe burn patients, so they had burn wounds in many locations on the body, but the common characteristic was that 100% had burn wounds on the head, face, and neck area.

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4.2. Subclinical characteristics of study patients

4.2.1. Characteristics of non-invasive assessment

SpO_2 index:

Although it has been proven effective in monitoring respiratory status in emergency situations, in cases of CO poisoning the SpO_2 index is considered inaccurate [7]. The SpO_2 index of group 1 was 96.3 ± 2.9% and that of group 2 was 97.2 ± 3.2%. The SpO_2 index was all high and according to the assessment criteria, the patients did not have respiratory failure. That is the same conclusion as the studies on situations of CO poisoning by Rehberg (2009) and Mlcak (2020) [8], [9]. The reason is that conventional pulse oximetry devices cannot distinguish between COHb and HbO_2.

SpCO index:

The SpCO index was measured using a Radical-7 monitor from Masimo (USA). Research by Piatkowski (2009), and Feiner (2013) has proven that the Radical-7 monitor accurately detects hypoxia in the blood and accurately detects carboxyhemoglobin [10], [11]. Although some studies have not fully confirmed the accuracy of this device, the benefits of a device that can detect CO poisoning early and non-invasively cannot be denied [12].

The SpCO index depends on the time and circumstances of the fire. Inhalation injury patients must have their SpCO index checked upon admission. Our study results on patients with a confirmed diagnosis of inhalation injury show that patients hospitalized early tend to have a high SpCO index. Hospitalized patients had an average index of 15.7%, in the first 5 hours the SpCO index was 8.3 ± 7.6%, then from the 6th to 12th hours it was 6.9 ± 8.7%. When patients were admitted to the hospital after 12 hours, the SpCO index visibly dropped, and most of these patients were not found to have CO poisoning. This may explain the high rate of victims in fires who often die before being hospitalized.

The process of tracking changes in the SpCO index gradually decreases over time. The patients were treated according to the treatment regimen for inhalation injury and CO poisoning. After 6 hours, the SpCO index reached the limit of 10% and continued to decrease in the following hours. No patient had CO detected by the meter after 72 hours. This result corresponds to the pathophysiology of CO poisoning, in conditions of 100% O_2, the half-life of CO is less than 90 minutes. With hyperbaric oxygen at 3 ATA pressure, the half-life of CO is reduced to 23 minutes. The only appropriate treatment for significant CO poisoning is hyperbaric oxygen therapy (HBOT) [13].

However, the study patients were severe burn patients who were not suitable for HBOT treatment using pressure chambers. When admitted to the hospital, all patients had their SpCO index measured, after endotracheal intubation, mechanical ventilation was adjusted to oxygen ventilation with 100% FiO_2 mixing for 6 hours.

The SpCO index upon admission depends not only on time but also on initial emergency treatment. In respiratory

emergency measures, the main measures are oxygen supply, endotracheal intubation, and mechanical ventilation. In the group 1, only 50% of patients received oxygen, 63.3% less than the group 2. The rate of endotracheal intubation is 35% and mechanical ventilation is 25% but the number is less than group 2. This is the main cause of the high pre-hospital death rate. Part of the reason is that measures to diagnose and monitor poisoning are limited and not many medical staff are regularly trained in this emergency.

4.2.2. Characteristics of invasive assessment methods

In measures to assess and monitor respiratory emergencies, arterial blood gas testing is very important. However, studies on arterial blood gases in CO poisoning show very notable problems.

According to Jor (2008), it was found that arterial PaO_2 monitoring was very abnormal in cases of CO poisoning. This is because partial pressure only describes the tendency of gas molecules to escape from the solvent in which they are contained. If the solubility of oxygen (O_2) in the blood is changed by the binding of CO to hemoglobin, the O_2 content will change but the partial pressure will remain the same (as long as the gas mixture with which the blood is in equilibrium remains constant). The cause of death in CO poisoning is reduced O_2 content in the blood because the binding sites of oxygen on hemoglobin are blocked by CO, leading to insufficient oxygen supply to the tissues. This will produce lactic acidosis as a consequence of anaerobic respiration, which may be the only abnormality in the blood gas analysis if carboxyhemoglobin is not measured directly. It can be seen in our study that blood lactate in group 1 was high at 4.8mmol/l, but there was no difference in group 2 with p = 0.08. PaO_2 concentration may decrease slightly at the scene of poisoning, but immediately after the patient is transferred, PaO_2 tends to increase again and increase higher than normal [14].

Moon et al. (2020) study of adult patients with CO poisoning on 340 patients also showed a similar situation [15]. The results of arterial blood gas PaO_2 upon admission in patients in Moon's study were 192mmHg (161 - 225), similar to our study results of 168.1mmHg. This can easily cause misassessment of CO poisoning in medical facilities that do not have tests or diagnostic tools for CO poisoning. Therefore, it is recommended that all burn patients with risk factors be maintained on high-concentration oxygen or artificial ventilation despite testing methods or functional exploration. got good results.

4.3. Clinical characteristics and results of study patients

**** Hospital admission time***

The study patients were adults (18 - 65 years old) and were hospitalized within 72 hours of burn injury. In the treatment of CO poisoning, emergency measures are very important but must also be applied during the half-life of CO to be most effective. The half-life of CO is 4 to 5 hours, but adequate oxygen alone can reduce the half-life to 1 hour [16].

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Therefore, patients in group 2 had a later hospitalization time than patients in group 1 because one of the reasons was that they used more emergency respiratory measures (Table 3.3). The study patients were all inhalation injury and severe burn patients so they were transported to the Burn Hospital sooner, after 1 hour at the earliest and 33 hours at the latest.

**** Classification of inhalation injury***

Our study applied Endorf's (2007) method, which is also widely used today, to diagnose the degree of inhalation harm by using bronchoscopy pictures [17]. Numerous studies have been mentioned about inhalation injury and CO poisoning, but none have included data on the relationship between the severity of inhalation injury and CO poisoning levels. CO poisoning patients mainly had grade 2 (55%) and grade 3 (30%), with 1 patient with the most severe inhalation injury being grade 4. This patient was admitted to the hospital 2 hours after a fire accident and measured CO index of 19% at the time of admission. The majority of patients with grade 1 inhalation injury had an average recorded CO index comparatively lower, 3.3 ± 5.6%. Focusing mainly on patients with grade 2 inhalation injury with an average CO index of 6.9 ± 8.2%. Grade 3 of inhalation injury had CO poisoning and the average CO index was high, 13.3 ± 6.3%. SpCO index increases corresponding to the severity of inhalation injury, between mild (grade 1 - 2) and severe (grade 3) ($p < 0.05$). Thereby showing the relationship between respiratory burns and CO poisoning as well as the grade of inhalation injury and CO index right in the diagnosis upon admission to the hospital.

**** The mortality and risk factors***

The study patients were inhalation injury patients who were evaluated as severe burn patients. According to previous studies in Vietnam, the average rate of inhalation injury is over 70% [6]. Factors that could increase the mortality rate considered in the study including CO concentration and time of hospitalization were not statistically significant because the patients were all diagnosed and treated according to the CO poisoning protocol. The patient's age factor is statistically significant with $p < 0.05$ and the risk ratio HR was 1.035; 95% confidence interval [1.009 - 1.061]. The burn area is also a risk factor for death for patients with inhalation injury and is used in formulas to calculate mortality rates.

5. CONCLUSION

The average SpCO index of inhalation injury patients upon admission is 15.7% and the poisoning rate was 40%. Patients with inhalation injuries who were hospitalized early had respiratory indicators that were not different between patients with CO poisoning and non-CO poisoning. The SpCO index is proportional to the severity of the grade of inhalation injury. After admission, patients received effective treatment for CO removal and the SpCO index did not correlate with mortality.

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CHARACTERIZATION OF *ESCHERICHIA COLI* ISOLATED FROM CHRONIC WOUND PATIENTS IN LE HUU TRAC NATIONAL BURNS HOSPITAL

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SUMMARY

Escherichia coli is responsible for many infections that affect burns and wound healing. They are highly resistant to antibiotics. Thus, the antimicrobial susceptibility pattern in burn and chronic wound infection may be useful in treating E. coli infections.

This study aimed to determine the prevalence and the antibiotic susceptibility of E. coli in burn and chronic wound infection in the Le Huu Trac National Burns Hospital from January 2021 to May 2023. E. coli were identified and the antibiotics susceptibility testing was performed using the VITEK 2 automated system. A total of 4326 samples were cultured. There were 41 (0.95%) samples positive and 4285 (99.05%) samples negative for E. coli. The E. coli infected were more common in males (n = 22; 53.66%) than in female patients (n = 19, 46.34%). The infection was the highest in farmers (n = 25; 60.98%), followed by the self-employed (n = 8; 19.51%) and retired (n = 8; 19.51%).

E. coli was highly sensitive to Fosfomycin (100%), Carbapenem class (> 90%), Colistin (92.31%), and Amikacin (87.18%) but resistant to Pefloxacin (100%), Minocycline (100%), Penicillins class (> 90%), and Trimethoprim-Sulfamethoxazole (84.62%). The use of Fosfomycin, carbapenem class, Colistin, and Amikacin are effective against E. coli and can help prevent the spread of infection.

***Keywords**: Escherichia coli (E. Coli), antibiotic, resistant, burns, wound*

1. INTRODUCTION

Burn injury and chronic wounds is a global public health concern. It causes damage to the skin - the largest organ in the human body. The skin functions as a barrier against infection, immunological defense, homeostasis, thermoregulation, and sensation. Burn injury results in 265,000 deaths annually, with nearly half of these occurring in South-East Asia [1].

Infection is a leading cause of mortality and morbidity, it also prolongs hospital stay following burn injury and chronic wounds. It causes a significant financial burden on developing countries such as Vietnam. Most burn wounds and chronic wounds are

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contaminated by bacteria from normal skin or hospital environments. Nosocomial infections are more common in burn wound and chronic wound patients compared to other wards [2]. Infection is one of the largest barriers to improved burn wounds and chronic wound outcomes in Vietnam. Most burn injuries and chronic wounds occur in rural areas. This further complicates their timely and appropriate treatment due to a lack of finances and infrastructure.

E. coli can be found as part of the normal human intestinal flora that may cause infections with potentially severe complications, including death. *E. coli* is a leading cause of community-acquired sepsis, a life-threatening condition. *E. coli* is the most common pathogen cause of death relevant to antibiotic resistance, particularly among older adults [3]. The burn wound and chronic wound patients may be at greater risk of *E. coli* infection and may be more challenging to manage due to the increased likelihood of antibiotic resistance.

The *E. coli* antimicrobial sensitivity and resistance data are important to facilitate treatment before antibiotic susceptibility results and prevent further multidrug-resistant organisms. Currently very few data on the *E. coli* infected and its antibiotic-resistant pattern among burn injury and chronic wounds infected patients in Vietnam. The *E. coli* antibiotic-resistant pattern data is important in empirical antibiotic prescribing and preventing further multidrug-resistant organisms. Thus, this study aims to document the *E. coli* profile of burn wounds and chronic wound infections at the Le Huu Trac National Burns Hospital.

2. MATERIALS AND METHODS

This was a retrospective study of burn wounds and chronic wound infection at the Le Huu Trac National Burns Hospital. The *E. coli* identification data were collected from January 2021 to May 2023 (29 months), and the antibiotic susceptibility testing data was used during the study period and before January 2021. The baseline characteristics specific burn wounds, and chronic wound infection data were collected.

2.1. Study Design

A total of 4.326 samples were collected; these samples included sterilized swabs, tissues from the infected wounds, urine, sputum, and blood.

2.2. Isolation, Identification, and Antimicrobial Susceptibility Testing

Standard microbiological techniques were used to culture samples. Gram staining, colony morphology. The identification and antimicrobial susceptibility testing were performed using the VITEK 2 automated system.

2.3. Data Analysis

Data were analyzed using R software version 4.3.0 (R Foundation for Statistical Computing, Vienna, Austria). $P < 0.05$ was considered statistically significant.

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3. RESULTS

3.1. Patient baseline characteristic

Table 3.1. *E.* coli infected patient demographics

Characteristic	n	Overall, n = 41	Female, n = 19	Male, n = 22	*p-value*
Age, median (min, max)	41	69 (47, 90)	81 (66, 90)	56 (47, 80)	< 0.001[1]
Occupation, n/N (%)	41				0.013[2]
Farmer		25/41 (60.98%)	11/19 (57.89%)	14/22 (63.64%)	
Retire and > 60		8/41 (19.51%)	7/19 (36.84%)	1/22 (4.55%)	
Self-employed		8/41 (19.51%)	1/19 (5.26%)	7/22 (31.82%)	
Outcome, n/N (%)	41				< 0.001[2]
Death		3/41 (7.32%)	0/19 (0.00%)	3 /22 (13.64%)	
Excellent		9/41 (21.95%)	5/19 (26.32%)	4/22 (18.18%)	
Fair		5/41 (12.20%)	5/19 (26.32%)	0/22 (0.00%)	
Good		10/41 (24.39%)	8/19 (42.11%)	2/22 (9.09%)	
Poor		11/41 (26.83%)	1/19 (5.26%)	10/22 (45.45%)	
Unidentified		3/41 (7.32%)	0/19 (0.00%)	3/22 (13.64%)	
Length of Stay, median (min, max)	38	18 (1, 108)	32 (7, 108)	13 (1, 63)	0.017[1]
Unknown		3	0	3	

[1]*Wilcoxon rank sum test*
[2]*Fisher's exact test*

The demographics of patients are presented in Table 3.1. The total of the infected cases were 41, male population (n = 22, 53.66%), female population (n = 19, 46.34%). The mean age of the cohort was 69.93 (median 69, range 47 - 90). The majority of infected patients were found in farmers (n = 25, 60.98%), followed by retired and self-employed (n = 8, 19.51%, each group). Length of stay at the hospital averaged 28.84 days (median 18, range 1 - 108). The mortality rate was 7.32% (n = 3).

3.2. Antibiotic susceptibility testing

Table 3.2. Antibiotic Susceptibility Pattern of *E. coli*

Classes	Antibiotics	Sensitive n (%)	Resistant n (%)	Intermediate n (%)	Total
Aminoglycosides	Amikacin	34 (87.18)	5 (12.82)	0 (0)	39
	Gentamicin	20 (51.28)	19 (48.72)	0 (0)	39
	Tobramycin	9 (34.62)	13 (50)	4 (15.38)	26
	Isepamicin	1 (33.33)	2 (66.67)	0 (0)	3
Carbapenem	Imipenem	35 (89.74)	4 (10.26)	0 (0)	39
	Meropenem	36 (92.31)	1 (2.56)	2 (5.13)	39
	Ertapenem	12 (92.31)	0 (0)	1 (7.69)	13
Fluoroquinolone	Ciprofloxacin	6 (15.38)	31 (79.49)	2 (5.13)	39
	Levofloxacin	3 (13.04)	18 (78.26)	2 (8.7)	23
	Norfloxacine	3 (23.08)	10 (76.92)	0 (0)	13
	Pefloxacin	0 (0)	3 (100)	0 (0)	3
Penicillins	Ampicillin	0 (0)	13 (100)	0 (0)	13
	Piperacillin	1 (3.85)	25 (96.15)	0 (0)	26
	Ticarcillin	1 (3.85)	24 (92.31)	1 (3.85)	26
Beta-lactam combination agents	Ticarcillin-clavulanate	6 (23.08)	11 (42.31)	9 (34.62)	26
	Piperacillin - Tazobactam	24 (80)	4 (13.33)	2 (6.67)	30
	Amoxicillin - clavulanic acid	6 (46.15)	5 (38.46)	2 (15.38)	13
Cefems	Cefepime	27 (69.23)	12 (30.77)	0 (0)	39
	Cefotaxime	3 (23.08)	10 (76.92)	0 (0)	13
	Ceftazidime	16 (41.03)	21 (53.85)	2 (5.13)	39
Monobactam	Aztreonam	9 (34.62)	16 (61.54)	1 (3.85)	26
Lipopeptides	Colistin	12 (92.31)	1 (7.69)	0 (0)	13
Fosfoycins	Fosfomycin	13 (100)	0 (0)	0 (0)	13
Tetracyclines	Minocycline	0 (0)	3 (100)	0 (0)	3
Folate Pathway Antagonists	Trimethoprim - sulfamethoxazole	6 (15.38)	33 (84.62)	0 (0)	39

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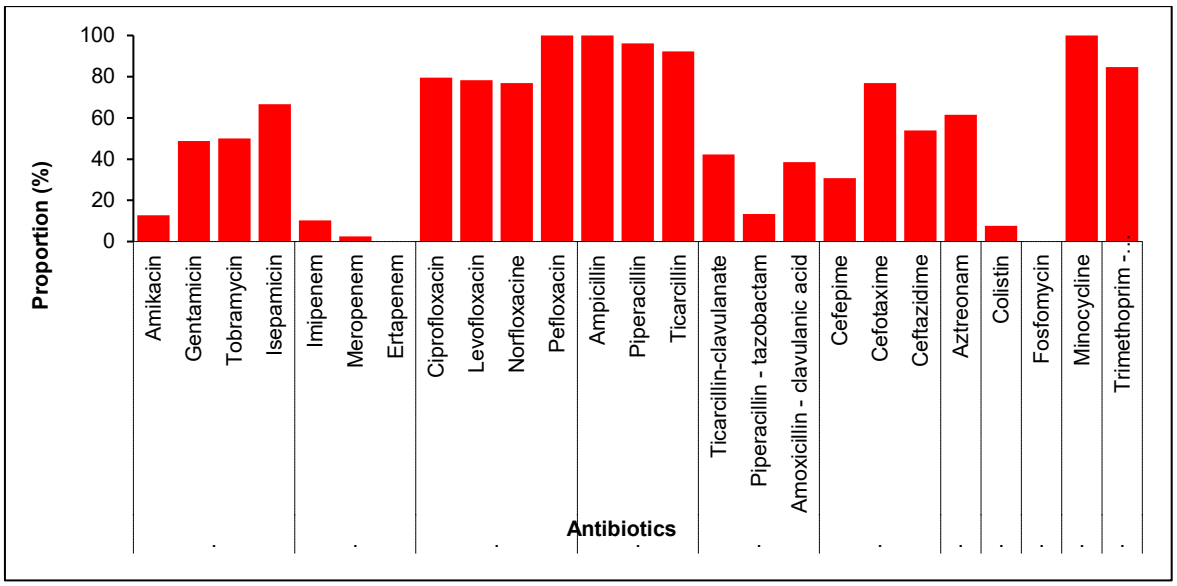

Figure 3.1. Antibiotic-resistant patterns

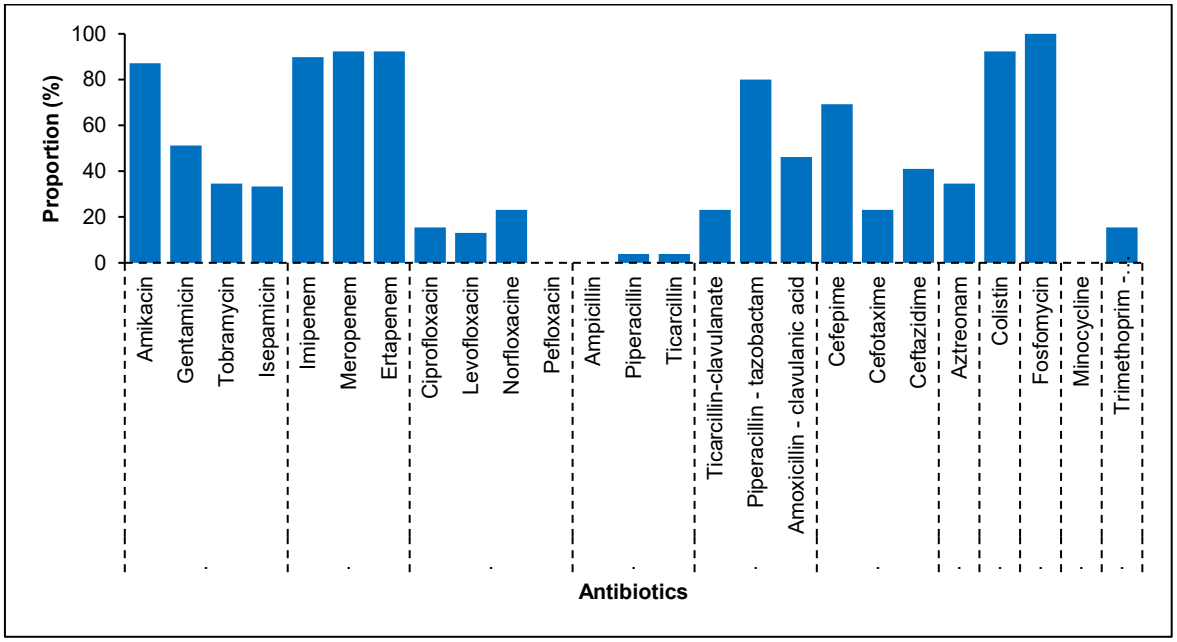

Figure 3.2. Antibiotic sensitivity patterns

Antibiotic susceptibility testing of *E. coli* is presented in Table 3.2. The resistance and sensitivity of *E. coli* to antibiotics are presented in Figure 3.1 and Figure 3.2, respectively.

E. coli was the highest resistant to Pefloxacin (100%), Minocycline (100%), Penicillins class (> 90%), and Trimethoprim-Sulfamethoxazole (84.62%).

E. coli was the highest sensitive to Fosfomycin (100%), Carbapenem class (> 90%), Colistin (92.31%), and Amikacin (87.18%).

4. DISCUSSION

The present study aims to highlight the *E. coli* sensitive and resistant to antibiotics causing chronic wound infections in Le Huu Trac National Burns Hospital.

The majority of chronic wound patients were males (53.66%) compared to females (46.34%), this finding is in line with other studies [4, 5]. This may be due to rather than women, men tend to be exposed to risk factors without taking sufficient precautionary measures [4]. The majority of the chronic wound patients in this study were adults. Our data are consistent with the previous study [6].

E. coli antimicrobial resistance was a serious problem in this cohort. Risk factors for acquiring resistant *E. coli* include previous hospitalization, invasive procedures, advancing age, and inappropriate antibiotic prescribing [1]. The *E. coli* infected patients rate was approximately 1.02%, which is lower than in other studies [7].

In the present study, *E. coli* was highly sensitive to Fosfomycin (100%), Carbapenem class (> 90%), Colistin (92.31%), and Amikacin (87.18%) but resistant to Pefloxacin (100%), minocycline (100%), Penicillins class (> 90%), and Trimethoprim-Sulfamethoxazole (84.62%). The results were consistent with other studies that a low resistance rate was seen for meropenem and colistin (8.33%); and the highest resistance was seen for Ampicillin (100%) followed by Trimethoprim/Sulfamethoxazole (91.67%), Amoxicillin/clavulanic acid (83.33%), Aminoglycosides (66.67%), Ciprofloxacin (66.67%) [8]. Such high resistance may be due to the inappropriate use of these antibiotics. This study was performed on the VITEK 2 automated system for identification and antibiotics susceptibility testing that provides accurate results and removes the requirement of human analysis and error of results [9].

Proper antibiotic prescribing can be improved by education on infection control for medical doctors and by the use of burn unit antibiograms according to guidelines. In addition, cleaning protocols should be adhered to as they are highly effective in removing pathogens. The *E. coli* resistance increased with the length of stay in the hospital, possibly due to the pathogens adapting to the hospital environment or the improper use of antibiotics. Amikacin was most effective for Gram-negative organisms.

The biggest challenge in managing burn and chronic wound infections is the appropriate selection and use of antibiotics. The burn wound and chronic wound microbial evolve rapidly, with multiple pathogens species invading the tissue at one time. Thus, the use of antibiotics is quite complicated in infected burn wounds and chronic wounds. The ineffective and non-regulated use of antimicrobials causes the emergence of multidrug-resistant bacteria which threaten the prognosis of burn injuries and chronic wounds. Therefore, constant monitoring of infections and antibiotic susceptibility patterns in burn and chronic wound patients is critically important [2, 10].

Antibiotic resistance is gradually swooping down on all the antibiotic classes. The multidrug-resistant pathogens may persist for months in a

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patient's body. Therefore, microbiological surveillance and identification of pathogens should be done before using antibiotics. Moreover, the inappropriate use of antibiotics should be avoided. Pathogens of burn wounds and chronic wounds are dynamic changing and diversifying over time [10]. The antibiotic susceptibility patterns of the burn wound and chronic wound pathogens are critical. Physicians must evaluate the wound to spot the most common organisms causing infections. The Le Huu Trac National Burns Hospital should regularly check on the changing antibiotic sensitivity data for common pathogens and be recognized as a core component of the burn and chronic wound treatment protocol. Therefore, this study is important for the establishment of a strict antibiotic usage policy in hospitals.

The study results showed that Fosfomycin, Carbapenem class, Colistin, and Amikacin are effective against *E. coli;* and Pefloxacin, Minocycline, Penicillins class, and Trimethoprim-Sulfamethoxazole are very low-effective against *E. coli*.

5. CONCLUSIONS

Fosfomycin, Carbapenem class, Colistin, and Amikacin were good choices in treating *E. coli*-infected chronic wound and burn wound patients at the Le Huu Trac National Burns Hospital. Further infection surveillance should be encouraged to help facilitate appropriate antibiotic prescribing and to prevent the further emergence of multidrug-resistant *E. coli*.

Conflict of interest

None declared.

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PATHOGENIC MICROBIOTA IN THE ORAL AND NASAL CAVITY OF HEALTHY INDIVIDUALS AS A POTENTIAL SOURCE OF INFECTIONS

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ABSTRACT

Oral microbiota is personalized and varied among human habitats. Detection and identification of pathogenic bacteria and fungi are considered as a strategy for the prevention and control of infectious diseases. To date, no studies have investigated the prevalence of bacterial pathogens and fungi in healthy individuals in Vietnam, particularly the ethnic minorities.

This study aimed to evaluate the presence of aerobic bacteria and fungi in the oral and nasal cavities of Jrai healthy individuals in the Central Highland. Oral and nasal swab samples of 140 healthy Vietnamese were collected. Microbiological procedures were performed using standard techniques. A total of 220 bacterial isolates were identified. Of which, 10% (22/220) were potentially pathogenic species including Klebsiella pneumoniae, Pseudomonas aeruginosa, Acinetobacter baumannii, Escherichia coli, Neisseria meningitidis, and Staphylococcus aureus. The most predominant bacteria family was Moraxellaceae (40%, 88/220), followed by Streptococcaceae (36.82%, 81/220).

Fungi were not detected in all samples. The oral and nasal cavity of healthy individuals harbors high frequencies of bacterial pathogens, suggesting its potential role as a source for these species. These pathogenic bacteria constitute the threat of their spread and the development of general infections. Infectious microbiota from the oral and nasal cavity should be examined as a preventive screening to control infectious diseases.

Keywords: *Microbiota, Biodiversity, Jrai people, Nasal Cavity, Oral Cavity*

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1. INTRODUCTION

Microorganisms can be found everywhere and are related to human life [1]. Healthcare-associated infections (HAIs) are transmissible and result from the interaction of multiple different factors in the infection chain. In this context, humans have been indicated as possible disseminators of pathogenic microorganisms in the environment [2]. A healthy individual's microbiology has been associated with many factors, such as age, gender, environment, and diet. The healthy human microbiota is personalized, varied systematically across human habitats [3]. Oral and nasal cavity microbiota play an important role in human health [1]. Both oral and nasal cavities are colonized by a system of microorganisms, including bacteria, fungi, and viruses [4]. This microbiota presents significant risk factors to human health, such as oral and body systematic diseases [1]. The oral microbiome can cause many diseases such as caries, periodontal and mucosal diseases and oral cancer [5], peri-implantitis, gastrointestinal system diseases, nervous system diseases [6], endocrine system diseases [7].

Tobacco smoking has significant adverse effects on human health. Smokers cause many diseases, such as organ system diseases and cancers [8]. The oral and nasal cavity microbiota have direct contact with cigarette smoke and may be significantly affected. Numerous toxicants in cigarette smoke can contribute to modifications of the oral and nasal cavity microbial ecology [9]. Although the microorganisms were infrequently detected in human oral and nasal cavity samples, few studies reported microorganisms that may be causing serious systemic infections by conventional culture methods [10]. This study aimed to examine the presence of potentially pathogenic aerobic bacteria and fungi in the oral and nasal cavity of healthy individuals by conventional culture methods to prevent the spread of infectious microorganisms that are risk factors for human health. Furthermore, we also investigated whether smokers modified the oral and nasal cavity microbiota diversity.

2. MATERIALS AND METHODS

Ethics statement

All the healthy individuals agreed to participate in the study after they were explained in detail about the study and written informed consent was obtained from all participants before sampling. All oral samples collected were anonymized after the completion of the sampling. The study was approved by the institutional review board of the Vietnam Military Medical University (VMMU), Hanoi, Vietnam.

Sample collection and processing

This was a cross-sectional, descriptive epidemiological study, performed in July 2020 on 140 Jrai people in the Central Highland region of Vietnam. All the participants had no symptoms of periodontitis or sore throat or any systemic diseases. The participants were classified into three groups of age: the first group included forty-two individuals aged from 1 to 12 years (Children, n = 42), the second group included thirty-nine individuals aged from 13 to 18 years (Adolescents, n = 39), and the third group included fifty-nine individuals over 18 years (Adults, n = 59). The oral and nasal swab samples were

collected from each participant and each sample was placed in sterile tubes containing 3 ml of Brain Heart Infusion (BHI) broth (Merck, Kenilworth, New Jersey, USA). Totaling 280 swab samples (140 oral and 140 nasal specimens) were collected from 140 participants. Samples were collected immediately after the application of routine oral hygiene. Participants did not use any antibiotics before collection.

Identification of bacteria and fungi

The determination of Gram-positive and Gram-negative bacteria strains using the Gram stain method. Standard conventional culture methods were also applied to isolate aerobic bacterial and fungi. Briefly, samples were used to grow aerobically on Blood agar, Chocolate agar, and Sabouraud Dextrose agar (Merck, Kenilworth, New Jersey, USA) and then tested for further specific determination. Once identified, the colonies were selected to run an identification analysis by the VITEK MS system (BioMérieux).

Statistical analysis

The species composition of microbiota detected in oral cavities and the prevalence of particular species were compared between the three groups and analyzed statistically. Continuous variables were compared using the Mann-Whitney U test or Kruskal-Wallis test, categorical variables were compared using the Chi-square or Fisher exact test. p-values less than 0.05 were considered significant.

3. RESULTS

Characteristics of Vietnamese participants

Table 3.1. Characteristics of Vietnamese participants.

Characteristics	Total (n = 140)	Children (n = 42)	Adolescents (n = 39)	Adults (n = 59)	p
Age (years), mean (SD)	21.06 (14.83)	5.93 (0.5)	17.44 (0.2)	33.73 (1.76)	< 0.001
Gender (male/female)	67/73	17/25	31/8	19/40	< 0.001
Smoking status					0.002
Current-smoker	14	0	2	12	
None-smoker	126	42	37	47	
Drinking status					0.014
Current-drinker	6	0	0	6	
Non-drinker	134	42	39	53	

Age was compared using the Kruskal – Wallis test; smoking and drinking status were compared using the Pearson Chi-Square test.

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The characteristics of the Vietnamese participants were shown in Table 1 there was a significant difference among groups on age ($p < 0.001$), gender ($p < 0.001$), smoking status ($p = 0.002$), and alcohol consuming ($p = 0.014$).

Colonized participants

Microscopic examinations of the oral and nasal swab cultures and laboratory tests showed the presence of various microorganisms belonging to different genera, species, and strains of bacteria in participant groups analyzed. The oral and nasal cavity of 140 (100%) participants were colonized by bacteria; of these participants, 42.85% (60/140) carried only one species of bacteria, and 57.15% (80/140) carried two species simultaneously. Thus, the participants were colonized by multiple species of aerobic bacteria.

Bacterial and fungi isolates in the oral and nasal cavity

Table 3.2. Species of aerobic bacteria (n = 15) isolated from the oral and nasal cavity of Vietnamese

Bacteria species (n = 15)	Number of isolates: n (%)	Group			p
		Children	Adolescents	Adults	
Gram-negative	112 (50.9)				
Moraxella catarhalis	86 (39.1)	28	24	34	0.655
Klebsiella pneumoniae	10 (4.55)	2	3	5	0.765
Pseudomonas aeruginosa	7 (3.2)	2	2	3	0.996
Ralstonia pickettii	2 (0.9)	1	1	0	0.476
Acinobacter baumanii	2 (0.9)	0	0	2	0.248
Herbaspirillum huttiense	2 (0.9)	1	0	1	0.649
Escherichia coli	1 (0.45)	0	1	0	0.271
Neisseria meningitidis	1 (0.45)	0	0	1	0.501
Neisseria mucosa	1 (0.45)	0	1	0	0.271
Gram-positive	108 (49.1)				
Streptococcus sp	64 (29.1)	17	19	28	0.712
Staphyloccocus epidermidis	25 (11.4)	7	9	9	0.595
Streptococcus mitis	16 (7.3)	5	2	9	0.302
Staphyloccocus aureus	1 (0.45)	1	0	0	0.309
Staphylococcus sp	1 (0.45)	1	0	0	0.309
Streptococcus salivarius	1 (0.45)	0	1	0	0.271
Total: n (%)	220 (100)	65	63	92	

Table 3.3. Families of aerobic bacteria (n = 8) isolated from the oral and nasal cavity of Vietnamese

Bacteria families	Number of isolates: n (%)	Percent (%)
Moraxellaceae	88	40.00
Streptococcaceae	81	36.82
Staphylococcaceae	27	12.27
Enterobacteriaceae	11	5.00
Pseudomonadaceae	7	3.18
Burkholderiaceae	2	0.91
Neisseriaceae	2	0.91
Oxalobacteraceae	2	0.91
Total	220	100

A total of 220 bacterial strains were isolated belonged to 15 different species. The most prevalent species was *Moraxella catarrhalis* (39.1%, 86/220), followed by *Streptococcus* sp. (29.1%, 64/220), and *Staphylococcus epidermidis* (11.4%, 25/220) (Table 3.2) The most common families were *Moraxellaceae* (40%, 88/220), followed by *Streptococcaceae* (36.82%, 81/220), and *Staphylococcaceae* (12.3%, 27/220) (Table 3.3). Potentially pathogenic bacteria were isolated including *Klebsiella pneumoniae* (4.55%), *Pseudomonas aeruginosa* (3.2%), *Acinetobacter baumannii* (0.9%), and *Escherichia coli*, *Neisseria meningitidis*, *Staphylococcus aureus* (0.45% each) (Table 3.2). However, there was no significant difference in the distribution of bacterial species among the three groups ($p > 0.05$). Furthermore, fungi were not detected in any of the samples.

A total of 140 participants, including 14 current smokers and 126 non-smokers, were investigated specifically for the presence and diversity of aerobic bacteria using a routine culture method. A total of 15 different bacterial species were detected in non-smokers compared, of which 5 species (*Moraxella catarrhalis, Streptococcus* sp., *Staphylococcus epidermidis, Streptococcus mitis,* and *Herbaspirillum huttiense*) were observed in current smokers. All the bacterial species isolated from the current-smokers were also found in non-smokers.

4. DISCUSSION

A large number of healthcare-associated infections is difficult to prevent, and thus making the problem of colonization for healthy individuals by pathogenic bacteria [11]. The individuals who carried the pathogenic bacteria can spread among the community, and the identification of potential sources of infection is a vital strategy to prevent and control infectious diseases. The present study has identified important pathogenic bacteria such as *Klebsiella pneumoniae,*

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Pseudomonas aeruginosa, Acinetobacter baumannii, Escherichia coli, Neisseria meningitidis, and *Staphylococcus aureus* in the oral and nasal cavity of local Vietnamese individuals. Therefore, the oral and nasal cavity can be a potential reservoir of pathogenic bacteria that can spread to the environment and susceptible individuals.

The six most common genera in the oral and nasal cavity including *Moraxella*, *Staphylococcus*, *Streptococcus*, *Haemophilus*, *Dolosigranulum*, and *Corynebacterium* have been recognized [12-14]. However, only three genera *Moraxella*, *Staphylococcus*, *Streptococcus* have been identified in this study, which is in line with a previous study [15]. *Streptococcaceae* is the second most common and this observation is also in concordance with the human oral microbiome database (HOMD) and another study reported that *Streptococcus* is higher abundant compared to other genera [16, 17]. Besides, the most frequent species isolated from the oral cavity are *S. salivarius*, *S. sanguis*, *S. mitis*, and *Streptococci* [18], of which, *S. mitis* is associated with oral cancer [19].

The oral microbiota is associated with many diseases [20], and the prevalence of colonization in the oral and nasal cavity by aerobic potentially pathogenic bacteria was 10%. These bacteria can enter the bloodstream from periodontitis, untreated carious lesions, or wound healing and cause infections [21, 22]. In this study, except *S. epidermidis* was isolated in all groups, *S. aureus,* and *Staphylococcus* sp. were only isolated only from children. Another study showed that *S. aureus* is frequent in the oral cavity. Therefore, it should be considered as a source of *S. aureus* which can spread and infect other individuals [23].

K. pneumoniae was found in all three groups of age and has emerged as a major source of antibiotics resistance genes. Surfaces contaminated with *Enterobacteriaceae* are well-documented sources of outbreaks of drug-resistant bacteria [24]. Therefore, *K. pneumoniae* can survive persistently in the oral and nasal cavity and is particularly noteworthy. *P. aeruginosa* and *Acinetobacter* spp. are important pathogens involved in hospital-acquired pneumonia. The oral and nasal cavity may be a major source of these respiratory pathogens [25].

In this study, seven *P. aeruginosa* isolates were identified in all three groups and two *A. baumannii* were found only in adults. Studies of the oral and nasal cavity colonization by *P. aeruginosa* and *A. baumannii* are scant and the relevance of these carriers should be enlightened [26, 27]. Asymptomatic oropharyngeal carriage of *N. meningitidis* is common in adolescence and young adults, corresponding to an increased risk of disease in these groups [28]. In the present study, *N. meningitidis* was isolated in a 22-year-old participant. *N. meningitidis* is a transient commensal of the human pharynx that causes severe diseases such as meningitis and bacteremia.

However, the mechanism of how *N. meningitidis* interacts with the pharyngeal microbiome to cause diseases is not clearly understood [29]. Similar to other previous studies [30, 31], we observed that smoking is related to the reduced diversity of oral and nasal microbiota and the potentially

pathogenic bacteria were uniquely found in non-smokers. The mechanisms by which tobacco smoking reduces the oral and nasal cavity microbiota diversity include acidity of saliva, toxicants, and depleting oxygen [32]. Thus, further studies are needed to explore whether tobacco smoke inhibits the growth of the oral and nasal bacteria species which is unique in non-smokers.

5. CONCLUSIONS

Potentially pathogenic bacteria are detected in the oral and nasal cavity, suggesting the adoption of strict hygienic actions should be applied to decrease the risk of cross-infection, or at least delay the occurrence of infections caused by pathogenic bacteria in local rural regions of Vietnam.

Conflict of interest

The authors declare that they have no conflict of interest.

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VITILIGO AND SURGICAL TREATMENT

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ABSTRACT

Objective: *Initial comments on the effectiveness of surgical treatment of vitiligo*

Research subjects and methods: *A prospective study on 12 cases of vitiligo that were successfully treated with autologous pigment cell transplant surgery. Research period from September 2018 to October 2022 at the Center for Plastic Surgery, Surgery & Regeneration - Le Huu Trac National Burn Hospital*

Results: *12 patients with an average age of 29, with vitiligo in several locations on the body, received pigment-containing cell transplant surgery. The graft adheres well, ensuring good coverage and assimilating the color of the vitiligo skin area with the surrounding healthy skin after about 12 months.*

Conclusion*: Pigment graft surgery is one of the effective methods of treating vitiligo and can be applied to large areas of the diseased skin.*

Keywords: *Vitiligo, pigment grafting*

1. BACKGROUND

Vitiligo is an autoimmune skin disease that targets melanocytes and causes depigmented patches visible as white spots. Like other autoimmune diseases, vitiligo has a very complex pathogenesis, including genetic, environmental, and random factors. Vitiligo is not only a devastating disease that affects appearance but also affects the patient's quality of life. Visible cosmetic defects often lead to psychological problems such as depression and anxiety, and cause low self-esteem and social isolation. The face and neck are areas where vitiligo is common, affecting the patient's aesthetics and psychology.

Treating vitiligo is quite difficult, many methods have been applied from internal medicine to surgery, but so far no method has brought optimal results because many other factors affect the results of treatment.

Surgical techniques often aim to provide melanocytes to previously depigmented areas [1] by dividing them into grafts and cell grafts (cultured melanocytes and cell grafts uncultured epidermis) [2, 3, 4]. Among them, the autologous culture-free melanin-keratinocyte transplantation (MKTP) procedure is one of the simplest cell transplantation techniques and is currently the most popular among dermatologists [5].

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It provides repigmentation rates of 50 - 100% with a donor-to-recipient ratio between 1:3 and 1:10, showing acceptable color matching in most treated cases [6]. Since it was first developed by Gauthier and Surleve-Bazeille in 1992 [7], several studies have been performed on the effectiveness of MKTP in the treatment of stable vitiligo [2]. However, studies with large databases and long-term follow-up, especially organ transplant outcomes after 6 years or longer, are rare.

Based on the above reasons, we conducted research with 12 cases of vitiligo on the face and neck using small thin autologous skin grafts, in order to achieve the goal of treating vitiligo, bringing the highest aesthetics to the patients. Research results and surgical methods will be presented in our report.

2. RESEARCH OBJECTS AND METHODS

2.1. Objects

12 cases of vitiligo were treated at the Center for Plastic Surgery, & Reconstruction - Le Huu Trac National Burn Hospital between September 2018 and October 2022.

2.2. Research Methods

The surgeries are monitored and evaluated for near and far post-operative results through the following criteria: Survival of the graft, healing of the surgical wound, complications if any, compatibility, and pigmentation development in the diseased area. physical.

- Prepare the patient:

+ Patients are examined and prescribed according to selection criteria.

+ Check pre-operative tests: X-ray of bones and joints, heart and lungs, basic blood tests, urine, electrocardiogram...

+ Prepare the donor area based on the size of the vitiligo skin area.

+ Take photos of the damage before, during and after surgery

- Surgical method:

+ Steps: Prepare the graft base: remove the dermis and dermis of the vitiligo skin area, and create a good graft base.

Skin is taken from the outer surface of the thigh, the area of skin to be removed is the area of vitiligo skin. The thickness of the skin piece is 0.15mm, skin removal tool: Padget knife. The skin removal area is covered with pig skin dermis and lightly compressed with a bandage.

+ The obtained piece of skin will be cut into many small pieces, an area of about 0.5 - 1cm in diameter.

+ Prepare the graft base: The vitiligo skin area is surgically removed from the epidermis and dermis in many small cells, the diameter of the cells is about 0.3 - 0.5cm, and these cells are about 1 - 1.5cm apart. (according to the space ratio 1:3), surgical tools: regular scalpel (Figure 4).

+ Stop the bleeding carefully, place small pieces of prepared skin graft on the newly created graft base, apply Vaseline gauze, and apply a light-pressure bandage.

+ Change the bandage on the grafted skin area 5 days after surgery.

Evaluate surgical results:

- Short-term result (level: Good, fair, and poor): Based on survival of the skin graft,

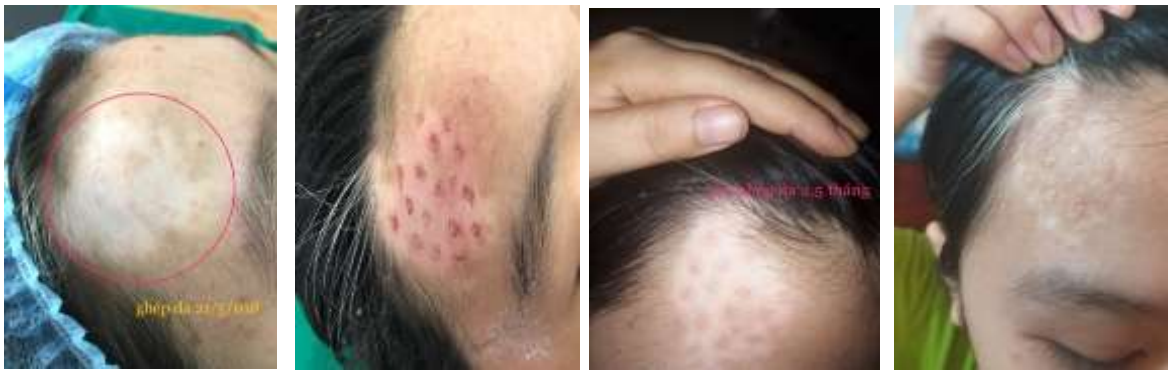
wound healing, hematoma under the graft, surgical wound infection... Criteria Evaluation is similar to the evaluation criteria of the autologous thin skin grafting method.

- Long-term result: Follow-up time after 3 months, 6 months, 1 year, 2 years, and after each year.

+ Good: The pigment patches in the vitiligo skin area are > 75% uniform in color and flat. The area where the skin was removed has no scars or changes in skin pigmentation.

+ Moderate: Skin pigmentation in the vitiligo area is 30 - 75% uniform in color, or the graft is uneven with the surrounding area of the graft. The area where the skin was removed has slight changes in skin pigmentation.

- Bad: The skin pigmentation in the vitiligo area is less than 30%. The area where the skin was removed leaves bad scars.



A. Vitiligo in the pigmented area of the forehead and right temple/

B. 1 day after pigment grafting surgery

C. 2.5 months after pigment graft surgery

D. 2 years after pigment graft surgery

Figure 1. Image of pigment grafting in the treatment of frontal vitiligo

3. RESULT

We have operated on 12 cases of vitiligo in the stable stage, at least the patients did not see the development of vitiligo for about 2 years. Patients had long-term follow-up data (24 - 40 months; median: 32 months. 12 patients were followed for at least 2 years. Duration of vitiligo varies from 2 to 15 years, with a median duration of average 5.0 years. The maximum surgical area per patient is 100cm² and the minimum is 10cm². Three patients (3.4%) had a family history of vitiligo. Diseases all patients received surgery to treat vitiligo on the face and neck.

Table 3.1. Patient characteristics

Sex: + Male + Female	**4 (33.3%)** **8 (66.7%)**
Age (years), median	21.1 ± 5.1
Duration of illness (years)	5.0 ± 0.8
Stability time (months)	23.5 ± 39.3
Surface of treated area (cm^2)	56.3 ± 27.3
Family history of vitiligo, n (%)	3/12 (25%)
Monitoring time, n (%)	
2 years	6/12 (50%)
3 years	6/12 (50%)

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Re-pigmentation results

Good re-pigmented lesions are considered successful (Figures 1, 2, 3, 4). Good repigmentation was achieved in 10/12 (83.3%), and 2/12 (16.7%) patients in the grafted area showed slight convexity of the graft, uneven surface, and not effective highly aesthetic (Figure 5).

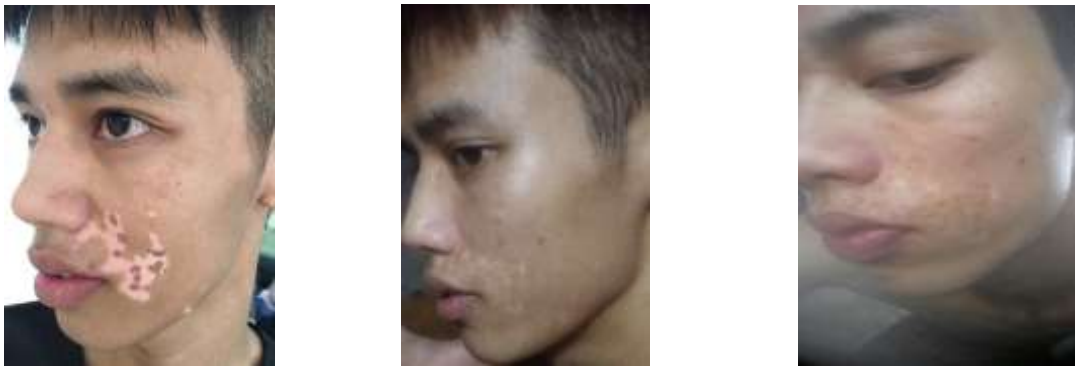
Table 3.2. Complications

Complications	Quantity	Percentage (%)
None	11	91.67
Incision site hematoma	1	8.33
Bacterial infections	0	0
Total (n = 12)	12	100

Table 3.3 Surgical results

Results	Quantity	Percentage (%)
Good	10	83,3
Fair	2	16,7
Poor	0	0
Total (n = 12)	12	100

All patients in this study performed good and fair, with the graft covering the vitiligo skin adhering well to the first incision in 12 out of 12 cases. The area for the skin does not leave bad scars, does not cause sequelae of contracture.



A: Vitiligo on the left cheek, upper lip | B: 3 months after skin graft surgery | C: 2 years after skin graft surgery

Figure 2. Image of pigment grafting in the treatment of vitiligo in the cheek, upper lip

A: Vitiligo on the right cheek, upper lip | After 2 years of skin grafting | After 3 years of skin grafting

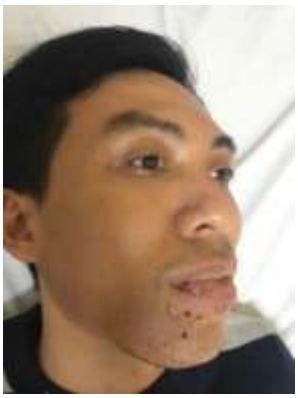
Figure 3. Image of pigment grafting in the treatment of vitiligo in the chin area of the lower lip

A: Vitiligo on the right cheek and upper lip

B: Prepare for pigment grafting

C: After pigmentation surgery

D: 13 months after skin grafting



E: 2 years after skin grafting

Figure 4. Image of pigment grafting in the treatment of vitiligo in the chin and lower lip area

A: Vitiligo at the lower chin

B: 2 years after pigment graft surgery.
Aesthetic results: the grafted area is uneven and rough

Figure 5: Image of pigment grafting in the treatment of vitiligo in the chin area of the left lower lip

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4. DISCUSSION

Diagnosis: Vitiligo can occur at any age, clinical diagnosis is based on the use of Wood's lamp light, ultraviolet rays shining on the skin will reveal that the depigmented skin will appear more rosy under the light bright.

The only symptom of vitiligo is that one part of the skin is lighter in color than the rest of the skin. Vitiligo skin areas are usually areas of skin frequently exposed to sunlight such as the face, neck, and limbs.

But for the most part, vitiligo skin areas usually do not cause discomfort or pain.

Some common causes: 20% of people with vitiligo have parents, siblings, or siblings with vitiligo. In some people, the disease is related to immune factors, leading to the body's immune system attacking and destroying melanocytes.

Maybe a few people get sick due to sudden stress, or an imbalance in oxygen molecules and antioxidants in the body. In addition, environmental factors: sunburn, chemical exposure, and unstable mental health can also be the cause of vitiligo.

4.1. Types of vitiligo

4.1.1. Non-segmental vitiligo

Non-segmental vitiligo is the more common type. If the first white patches are symmetrical, this suggests a type of vitiligo called non-segmental vitiligo. Growth will be slower if the patches are only one anatomical region of the body. The patches usually appear equally on both sides of the body, often appearing on areas of frequently exposed skin to the sun like the face, neck, and hands.

4.1.2. Segmental vitiligo

This type of disease is much less common and only affects about 5-16% of people with vitiligo, usually appearing between the ages of 4 and 10 years and affecting only one area of the body. Segmental vitiligo typically affects areas of skin attached to nerves that arise at the posterior roots of the spine, responding well to topical treatments.

4.1.3. Surgical treatment of vitiligo

Vitiligo is a difficult disease to treat. Many factors affect the treatment results such as: Location, extent of the diseased area, duration of the disease, combined treatment measures, and overall medical condition close...

In this study, with a rather modest number, we only give some initial comments on the pigment grafting method in the treatment of vitiligo, a method that many authors around the world believe is highly efficient.

Several surgical methods have been applied in the treatment of vitiligo, each method has its advantages and disadvantages. In all 12 patients in this study, we used pigment grafting. The grafts were only a little larger than the size of a punch, so it was similar to the miniature punch grafting method.

4.2. The mechanism of spreading of pigment cells after transplantation is as follows

Spread and accumulation: After pigment cells are transplanted into damaged skin, they will begin to spread and accumulate in the surrounding area.

Melanocytes can self-locate and develop into new skin cells. They will divide and duplicate to create many new pigment cells, thereby creating new skin and replacing skin areas damaged by vitiligo.

Recovery and regeneration: When new pigment cells have spread and accumulated enough in the damaged skin area, the process of skin recovery and regeneration will take place. The new melanocytes will provide pigment to surrounding skin cells and help regenerate the skin's natural structure and color. The result is that the damaged skin will be restored and have an appearance similar to the original healthy skin.

Surgical methods often aim to provide melanocytes to previously depigmented areas by dividing them into grafts and cell grafts (cultured melanocytes and non-melanocytes graft culture). Among them, the autologous non-cultured melanin-keratinocyte transplantation (MKTP) procedure is one of the simplest cell transplantation techniques and is currently the most popular among dermatologists. It provides repigmentation rates of 50 - 100% with a donor-to-recipient ratio between 1:3 and 1:10, showing acceptable color matching in most cases treated. Since it was first developed by Gauthier and Surleve-Bazeille in 1992 [7], several studies have been performed on the effectiveness of MKTP in the treatment of stable vitiligo.

Surgical Therapy

In the last decades, the surgical options for vitiligo underwent a lot of advances. The main basic methods for melanocyte transplantation are essentially five: punch grafting; suction blister grafting, thin dermo-epidermal grafts, non-cultured epidermal suspensions, and in vitro cultured epidermis with melanocytes or pure melanocytes suspensions [12].

4.3. Some factors related to treatment results

- Patient's age: The influence of age at surgery on treatment results is still unclear. Chen et al showed that patients under 40 years of age had better outcomes. However, according to some other authors, the influence of age is insignificant. In this study, we found that age was not a statistically significant covariate related to treatment success.

- Pathological location: According to Huggins with colleagues, more than 70% of patients with vitiligo in the perioral area have poor pigmentation regeneration [4]. However, patients with vitiligo skin around the mouth all have good results after colorectal graft surgery. In this study, there were 5/12 patients with vitiligo patches in the perioral area. All patients had good results after surgery.

- Treatment measures before surgery: Many authors show that patients receive medical treatment such as using UVB, UVA phototherapy, or other products. As a result, pigment regeneration is improved thanks to phototherapy before MKTP was not surprising. Zeng suggested that the combination with UVB phototherapy also increased the effectiveness of cultured autologous melanocyte transplantation [8]. Over the years, several studies have used post-transplant phototherapy to enhance repigmentation, although no studies have been performed to evaluate the role of phototherapy before surgery.

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Most of the 12 patients above said they did not use standard interventions of topical corticosteroids/calcineurin and phototherapy before surgery.

- Vitiligo stabilization time: The stability of vitiligo is considered an important parameter before considering any melanocyte transplantation technique. We found that different periods of disease stability were used as criteria for surgical indications. Some authors believe that 6 months of disease stabilization is sufficient, while others require 1 year for disease stabilization [9, 10]. Olsson even suggested that patients with stable vitiligo for less than 2 years should not be candidates for surgery [11]. Recurrence: Gang and colleagues showed a recurrence rate of 11% out of 177 patients. MKTP shows therapeutic promise and has been proven to be a safe and effective treatment for patients. Further improvements in implantation techniques may yield better results even in difficult-to-treat areas.

- A family history of vitiligo can significantly affect treatment results. Dimin Zhang's 2021 announcement showed that 79/2283 patients with a positive family history responded worse than other patients without a family history. People with a first-degree relative with vitiligo have a higher risk of developing the disease: nearly 6% compared with 1% or less in the general population [8].

Surgical results: Many authors around the world believe that surgical results are more stable and better with an evaluation period longer than 12 months. Our patients are no exception. Within 12 months, the studied patients were periodically re-examined, and usually after 12 months, the grafted skin had better results in terms of color uniformity in the white skin area (table 1 & 3).

5. CONCLUSION

Vitiligo is a difficult disease to treat. Many methods have been applied, including medical and surgical treatment. Pigment grafting is one of the promising treatment measures and is preferred by many doctors. However, to achieve high effectiveness, it is necessary to study a large number of patients to provide the most accurate indications for the treatment. This method is because many related factors affect treatment results.

In initial research with 12 patients, we found this to be a simple but quite effective treatment method for vitiligo, opening the door for further research with a larger number of samples.

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POSTOPERATIVE INFECTION *MYCOBACTERIUM ABSCESSUS* ASSOCIATED WITH LIPOSUCTION AND AUTOLOGOUS FAT GRAFTING: A NARRATIVE REVIEW

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SUMMARY

Liposuction and autologous fat grafting are common aesthetic procedures these days. Although these procedures are relatively safe, some severe complications sometimes happen affecting aesthetic results and the patient's quality of life. Postoperative infection of Mycobacterium abscessus after liposuction and autologous fat grafting is an uncommon complication along with untypical symptoms. This results in misdiagnosis and delays in proper diagnosis and treatments, prolonging the treatment period. This narrative review summarises cases of M. abscessus infection associated with liposuction and autologous fat grafting, then presents causes, diagnoses, preventive care, and treatments of such cases. This aims to enhance the awareness of this infection after aesthetic surgery and contributes to the appropriate prevention and treatment.

Keywords: *Mycobacterium abscessus, liposuction, autologous fat grafting*

1. BACKGROUND

In 2020, there were about 2.3 million people undergoing aesthetic procedures worldwide with liposuction being one of the top five popular (211,067 procedures) [1]. Modern liposuctions including power-assisted, ultrasound-assisted, and laser-assisted liposuctions have developed in addition to manual liposuction [2-5]. These procedures are mostly safe, but severe complications could happen due to improper manipulations [5]. Among liposuction-associated complications, infection is rare with < 1% of total cases mostly caused by staphylococci or streptococci [5-7]. Non-tuberculous Mycobacteria (NTM), namely *Mycobacterium abscessus*, *M. chelonae*, and *M. fortuitum*, were often detected as infections after surgery including liposuction. This negatively impacted aesthetic results and the patient's quality of life [8, 9]. Improper and delayed treatments were caused by difficulty in

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differential diagnosis and the use of empiric antibiotics. These prolonged the hospital stay, worsened clinical results, and caused recurrences [10].

M. abscessus infection post-liposuction is rare and hard to differentiate from other infections with untypical symptoms. Until now, there has been no standard treatment guideline. This narrative review collects 46 cases with *M. abscessus* after liposuction and autologous fat grafting from 25 clinical reports and case series. Among those, there were 28 cases (60.9%) of liposuction, 27 cases (58.7%), and 9 cases (19.6%) of combined liposuction and autologous fat grafting (Table 1.1). Liposuction at the abdomen and the back was performed in a majority of cases. Liposuction of the thigh, neck, arm, flank, and face is less common. Fat grafting is often conducted at the face, breast, buttock, and hands. Common combinations of liposuction and fat grafting included liposuction at the abdomen, flank, neck, arm, or thigh and fat grafting at the breast, buttock, or face.

Table 1.1. Summary of 46 cases with *M. abscessus* infection after liposuction and/or autologous fat grafting

Author/Year	Gender/age of patients	Liposuction/Fat grafting position	Onset time of symptoms from the surgery	Time from cosmetic procedure to resentation at the hospital	Time to detect *M. abscessus* after presentation
Murillo/2000 [43]	F/35	Liposuction: Abdomen	35 days	NR	NR
	F/37	Liposuction: Abdomen	30 days	NR	NR
	F/47	Liposuction: Abdomen and thighs	10 days	R	NR
	F/49	Liposuction: Abdomen	45 days	NR	NR
Akers/2000 [45]	F/63	Liposuction: Face	6 weeks	6 weeks	10 weeks
Newman/2005 [26]	F/46	Liposuction: Abdomen	3 months	3 months	2 months
Furuya/2008 [40]	F/38	Liposuction: Upper back	2 weeks	2 months	NR
	F/44	Liposuction: Abdomen	1.5 months	1.5 months	NR
	F/58	Liposuction: Abdomen	2 months	2 months	NR
	F/45	Liposuction: Upper back	3 months	3 months	NR
Galea/2009 [23]	F/55	Fat grafting: Hand	NR	4 days	NR
Engdahl/2014 [46]	F/42	Liposuction: Back, flank	NR	5 months	6 days
	F/40	Liposuction: Abdomen Fat grafting: Buttocks	NR	4 months	13 days
Ruegg/2015 [24]	F/39	Liposuction: Abdomen Fat grafting: Buttocks	2 months	5 months	NR

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Author/Year	Gender/age of patients	Liposuction/Fat grafting position	Onset time of symptoms from the surgery	Time from cosmetic procedure to resentation at the hospital	Time to detect *M. abscessus* after presentation
Hui/2015 [36]	F/41	Liposuction: Neck, upper arms, lower abdomen, thighs	NR	1 month	NR
Cai/2016 [39]	F/43	Liposuction: NR	3 weeks	4 months	NR
Yang/2017 [27]	F/29	Fat grafting: Face	5 days	NR	NR
Tung-Chen/2017 [22]	F/22	Liposuction: NR	5 months	6 months	NR
Cusumano/2017 [10]	F/31	Liposuction: NR	2 months	2 months	NR
Chang/2018 [34]	F/40	Liposuction: Abdomen Fat grafting: Face	6 weeks	3 months	NR
Lee/2019 [17]	F/49	Liposuction: Upper back	2 weeks	3 months	1 month
Escuredo/2020 [11]	F/66	Fat grafting: Breast	1 month	1 month	NR
	F/29	Fat grafting: Breast	NR	NR	NR
Chen/2020 [44]	12 females / 23-48	Fat grafting: face	6 - 90 days	NR	NR
Tan/2020 [35]	F/39	Liposuction: Abdomen Fat grafting: Breast	20 days	NR	NR
Su/2020 [37]	F/30	Fat grafting: Buttocks	2 weeks	11 weeks	NR
Moreno-Izquierdo/2020 [19]	F/42	Liposuction: arms and neck	2 weeks	5 weeks	NR
Yang/2021 [20]	F/28	Liposuction: Abdomen	8 days	3 months	45 days
Safe/2021 [38]	F/65	Liposuction: Abdomen Fat grafting: Buttocks	NR	NR	NR
Motawea/2022 [21]	F/23	Liposuction: abdominal flanks and back Fat grafting: gluteal region	2 weeks	2 weeks	25 days
Yeh/2022 [41]	F/34	Liposuction: Thighs and abdomen Fat grafting: Breast	3 weeks	3 weeks	5 weeks
Hill/2023 [47]	F/33	Fat grafting: Buttock	3 months	9 months	2 weeks
Tuấn/2023 [42]	F/32	Liposuction: Underarm, thigh, back Fat grafting: Buttock	1 month	2 months	3 weeks
	F/43	Liposuction: Abdomen, back	1 month	1 month	2 weeks

Author/Year	Gender/age of patients	Liposuction/Fat grafting position	Onset time of symptoms from the surgery	Time from cosmetic procedure to resentation at the hospital	Time to detect *M. abscessus* after presentation
		Fat grafting: Buttock			
	F/32	Liposuction: Abdomen, flank	1 week	2 months	2 weeks

This review aims to summarize the causes, and common symptoms caused by *M. abscessus* after liposuction and fat grafting, diagnosis method, preventive care, and treatments of this complication.

2. CAUSES

Liposuction and fat grafting are deemed to be safe with lower rates of complications. These complications are avoidable or self-limited [5, 12, 13]. Even though, poor infection control or ineffective surveillance systems in unlicensed beauty centers might cause site surgical infection. Particularly, the centers might not allow patients to carefully bath with an antiseptic solution, or wash surgical tools with contaminated water. Additionally, residual fat on the used cannulas is also a cause if they are not properly processed [14].

Preventions

Currently, there has been no standard prevention of surgical site infection of NTM after liposuction. Nevertheless, the adherence to surgical site infection prevention by WHO and the US Center for Disease Control and Prevention (CDC) could contribute to minimizing surgical site infection of NTM [15,16]. Careful bathing with appropriate antibiotic solution, preoperative prophylaxis, maintenance of a clear surgical environment, and careful sterilization of surgical tools help effectively prevent NTM. Because of the alcohol resistance and acid resistance of Mycobacterium species, normal antiseptic solutions for sterilizing surgical tools may not be effective and could diffuse pathogens via surgical tools. A recent study suggested effective agents against NTM including glutaraldehyde, 3-chlorhexidine, and povidone iodine [17]. However, further studies are required to confirm the applications of these agents.

Common symptoms of *M. abscessus* infection after liposuction and autologous fat grafting

In general, clinical symptoms of *M. abscessus* infection after liposuction and autologous fat grafting are untypical. After these procedures, non-infectious inflammation may occur as a body reaction against surgical trauma, leading to swelling or edema postoperatively [5]. Neira et al [18] suggested that modern techniques (e.g. laser-assisted liposuction) might cause milder inflammatory reactions than classical liposuction. However, our experience revealed that inflammatory reactions were equally less common for all types of liposuction, and no clear discrepancy of inflammation grades between different liposuction techniques.

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Surgical site abscesses accounting for 60.9% (28 of 46 patients) and fever accounting for 47.8% (22 of 46 patients) were the most common symptoms. Less common symptoms consisted of red inflammatory foci (32.6%), pain (26.1%), and surgical site exudate (28.3%). In addition, some cases manifested with surgical nodes (13.0%), swelling (15.2%), allodynia (10.9%), or induration (8.7%). Sometimes, patients felt fatigued or uncomfortable [19, 20]. Other patients could have a sense of burning hot or ulcers at the surgical sites [10, 11, 21].

Paraclinical characteristics

All patients had normal blood tension and heart rates [22]. Blood examination showed normal ALT, total bilirubin levels, and electrolyte levels [20, 22, 23]. However, on one hand, some studies indicated normal levels of white blood count, and other studies showed a mild elevation in the other hand [19, 22-27]. The level of C-reactive protein was also normal in some investigations [19, 22-25]. A few reports demonstrated that the inflammatory reaction was just transient postoperatively and did not cause any significant changes in inflammatory markers via examinations, even when a large amount of fat was aspirated [28-31]. Nevertheless, in cases of surgical infection, it could lead to distinct inflammatory reactions due to the activation of immune system reactions to protect the body from pathogens (e.g. viruses, bacteria) via a variety of biological pathways [32, 33].

On ultrasound results, there could be scattered abscesses, fluid fat foci, or heterogeneous irregulatory and hypoechoic injuries [22, 24, 27, 34-36]. Histopathologic images showed ulcerous or granular lesions [23, 34, 37, 38]. Meanwhile, fluid collection, abscesses, and air foci were seen in CT scans [10, 21, 26, 39-41].

Diagnosis

Often, patients visited hospitals lately for the treatment of complications caused by liposuction (83 days on average) [42]. Besides, the time to first symptoms and time of diagnosis of *M. abscessus* were often long (33 days on average), sometimes taking 3 months [42]. These reasons could result in treatment failure using initial antibiotics, high treatment costs, and failure in diagnosis.

Common samples for diagnosis were exudate, abscess fluid, necrotic/debrided tissues, culture/ biopsy of injured skin, or fluid collections. Diagnosis of *M. abscessus* was mainly based on the positive results to AFB or via 16s rRNA PCR [10, 19, 21, 24, 27, 35, 36, 42, 43]. Nevertheless, AFB results might be negative in some cases. This test could be really specific and might be negative at the first test until the transformation to positive in the following tests. Motawea et al. revealed that it took 8 days after the first negative results for the samples to be positive afterward [21]. Culture was the most frequent diagnosis method of *M. abscessus* which was used in 41 of 46 cases [10, 11, 19-23, 26, 34, 36, 37, 40-45].

However, the first results were often negative and required several following cultures [11, 20, 21, 23, 25-27, 36, 42,45]. Meanwhile, routine cultures often showed no bacteria developed. Yang et al. reported that it demanded 3 times culture to obtain a positive result of *M. abscessus* [20]. Additionally, the time to diagnosis of *M. abscessus* from the first visit due to *M. abscessus* infection after liposuction/autologous fat grafting was 6 - 70 days [20, 21, 25, 26, 41, 45-47]. It often took about 2 – 4 months from the first symptom to diagnosis. Some less common methods such as panel-reactive antibody and high-performance liquid chromatography were utilized to reinforce the diagnosis of *M. abscessus* [19, 40].

Antibiotics and treatment regimens

The response to antibiotic treatment was different between studies. It could be 7 days, 2 - 4 weeks, 8 weeks, or 3 months after the treatment [20, 21, 27, 35, 42, 45, 47]. When the patient was presented at the hospital, empiric antibiotics were often prescribed while waiting for susceptibility testing results. The most common antibiotics for treating *M. abscessus* were beta-lactam antibiotics which were reported in 35 of 46 cases (76.1%) (Table 3.2). Most antibiotic regimens included 1 – 2 drugs [10,20,23,24,26,27,34,36,38,39,41,42,44,45]. Even though, some authors preferred to use 3 drugs and above [37,41,42,47]. These empiric antibiotic regimens were poorly effective, resulting in antibiotic changes when *M. abscessus* had still not been confirmed [27, 41]. Sometimes, antifungal medicine such as fluconazole was added to the regimen [37]. These medicines were almost ineffective against *M. abscessus,* leading to long treatment times and high costs.

Table 3.2. Treatment regiments for *M. abscessus* infection after liposuction and/or autologous fat grafting in 46 cases collected

Author/Year	Gender/Age	Liposuction/Fat grafting position	Empiric antibiotics	Treatment regimen	Antibiotic treatment course	Follow-up time	Complications
Murillo/2000 [43]	F/35	Liposuction: Abdomen	NR	• AMK + CLR* • Abscess drainage	4 months	At least 12 months	NR
	F/37	Liposuction: Abdomen	NR	• CLR + CIP* • Abscess drainage	9 months	At least 12 months	NR
	F/47	Liposuction: Abdomen and thighs	NR	• AMK + CLR + CIP* • Abscess drainage	5 months	At least 12 months	NR
	F/49	Liposuction: Abdomen	NR	• AMK + CLR + CIP * • Abscess drainage	18 months	At least 12 months	NR
Akers/2000 [45]	F/63	Liposuction: Face	CFR (7 days)	• CIP + EMB + RIF + CLR* -> IMP (3 weeks) + CLR* (6 months) • Drainage	6 months	12 months	NR
Newman/2005 [26]	F/46	Liposuction: Abdomen	AMC + AZM	• Abscess drainage • FOX + IPM + AMK + AZM	NR	NR	NR
Furuya/2008	F/38	Liposuction:	NR	• FOX + AMK +	6 months	NR	Rash and

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Author/Year	Gender/Age	Liposuction/Fat grafting position	Empiric antibiotics	Treatment regimen	Antibiotic treatment course	Follow-up time	Complications
[40]		Upper back		CLR -> LZD • Drainage			leukopenia due to FOX Nephrotoxicity due to AMK
	F/44	Liposuction: Abdomen	NR	• CLR • Drainage	6 months	NR	NR
	F/58	Liposuction: Abdomen	NR	• LVX + CLR -> CIP • Drainage	6 months	NR	NR
	F/45	Liposuction: Upper back	NR	• AZM -> FOX + AMK + IPM • Drainage	22 months	NR	NR
Galea/2009 [23]	F/55	Fat grafting: Hand	Flucloxacillin	• Surgery and drainage • CLR + IPM + AMK	9 months	NR	NR
Engdahl/2014 [46]	F/42	Liposuction: Back, flank	NR	• AMP + FOX • Drainage • Debridement	6 months	NR	NR
	F/40	Liposuction: Abdomen Fat grafting: Buttocks	NR	• CLR + SXT + LVX • Drainage	6 months	NR	NR
Ruegg/2015 [24]	F/39	Liposuction: Abdomen Fat grafting: Buttocks	AMC + CIP	• CLR + TGC (12 days) + LZD (30 days) + AMK (12 days) *-> CLR + MXF (6 weeks)* • Drainage/NPWT • Debridement	20 weeks	5 months	Nausea owing to AMK and TGC Rash, hepatitis owing to LZD
Hui/2015 [36]	F/41	Liposuction: Neck, upper arms, lower abdomen, thighs	Flucloxacillin + TZP	• Debridement • AMK + CLR + LZD* • Corticosteroid	18 months	NR	Pancytopenia, liver disorders owing to LZD
Cai/2016 [39]	F/43	Liposuction: NR	FOX + CLR	• Debridement (delay) • AMK + LZD + IPM	8 months	6 months	Mild headaches and photophobia owing to AMK Peripheral neuropathy owing to LZD
Yang/2017 [27]	F/29	Fat grafting: Face	PEN +MTZ (3 days) -> TZP	• PZA + EMB + RIF + INH + LVX + AMK (at hospital) • MXF + CLR + EMB (12 months at home)*	15 months	2 years	Leukopenia due to AZM
Tung-Chen/2017 [22]	F/22	Liposuction: NR	AMX + cloxacillin	• AMK	4 weeks	NR	NR

Author/Year	Gender/Age	Liposuction/Fat grafting position	Empiric antibiotics	Treatment regimen	Antibiotic treatment course	Follow-up time	Complications
Cusumano/2017 [10]	F/31	Liposuction: NR	SAM, VAN	• Surgery and drainage • AMK+ FOX+ AZM -> AMK + TGC + AZM -> AMK + AZM + IPM-cislastatin-> CLO + AZM*	30 weeks	NR	Intolerance to antibiotics. Leukopenia owing to FOX. Hyperpigmentation owing to CLO
Chang/2018 [34]	F/40	Liposuction: Abdomen Fat grafting: Face	AMC + GEN	• CLR + MXF	1 year	6 months	NR
Lee/2019 [17]	F/49	Liposuction: Upper back	CFR	• Radical surgical debridement • MXF + CLR -> AKM + IPM-cilastatin*	6 months	NR	NR
Escuredo/2020 [11]	F/66	Fat grafting: Breast	AMC	• Drainage, fistulectomy • AMK + TGC*	16 weeks	NR	Recurrence
	F/29	Fat grafting: Breast	NR	• AMK + TGC*	3 months	NR	NR
Chen/2020 [44]	12 females / 23-48	Fat grafting: NR	Cephalosporin	• Surgery • AMK + cephalosporin + CLR/CIP*	1.5 years	3 – 7 years	Gastrointestinal discomfort, Abnormal liver function
Tan/2020 [35]	F/39	Liposuction: Abdomen Fat grafting: Breast	CXM + MTZ	• Debridement, curettage, drainage • CLR + IPM + AMK (at the hospital) • AZM + EMB + RIF + (at home)	7 months	8 months	Recurrence of masses after 8 months
Su/2020 [37]	F/30	Fat grafting: Buttocks	SXT + FLC + CLI + AMC	• TGC + AMK -> TZD + AMK + AZM *	NR	NR	NR
Moreno-Izquierdo/2020 [19]	F/42	Liposuction: arms and neck	NR	• AMK + IPM (1.5 month each) + CLR (7 months) • Incision and drainage	7 months	NR	NR
Yang/2021 [20]	F/28	Liposuction: Abdomen	CFP + MXF	• FOX + AMK + CLR + LVX + sulfamethoxazole • Incision and drainage	146 days	6 months	Liver function abnormalities
Safe/2021 [38]	F/65	Liposuction: Abdomen	LEX (7 days)	• CLR + MFX*	6 months	12 months	NR

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Author/Year	Gender/Age	Liposuction/Fat grafting position	Empiric antibiotics	Treatment regimen	Antibiotic treatment course	Follow-up time	Complications
		Fat grafting: Buttocks					
Motawea/2022 [21]	F/23	Liposuction: abdominal fanks and back Fat grafting: gluteal region	CLI	• Irrigation, debridement, sterile dressing • DOX (10 days) + AZM	NR	NR	NR
Yeh/2022 [41]	F/34	Liposuction: Thighs and abdomen Fat grafting: Breast	CFR + CIP -> TEC + DAP + CIP -> LVX	• CLR -> CLR + DOX + TGC + AMK • Debridement	9 months	6 months	Diarrhea, nausea, vomiting
Hill/2023 [47]	F/33	Fat grafting: Buttock	DOX+ LVX+ AMX + CLI + MIN + SXT + LEX + RIF	• In hospital (2 days): AMK + TGC + IMP-cilastatin + LZD* • Outpatient clinic (6 – 12 months): AMK + IPM + TZD + OMC* • Surgery	12 months	NR	Tinnitus and teeth discoloration
Tuan/2023 [42]	F/32	Liposuction: Underarm, thigh, back Fat grafting: Buttock	SAM + CIP + IPM-cilastatin	• Debridement, antibiotic irrigation, drainage. • AMK (3 weeks) + CIP (6 weeks) + Sulfamethoxazole (6 weeks) + CLR (6 months) • Methylprednisolone 1 mg/kg/day (2 weeks) then tapped by 1 mg/week during 2 months	6 months	6 months	Hyperpigmentation
	F/43	Liposuction: Abdomen, back Fat grafting: Buttock	SAM + CIP + IPM-cilastatin	• Debridement, antibiotic irrigation, drainage. • AMK (3 weeks) + CIP (6 weeks) + CIP (3 months) + CLR (6 months) • Methylprednisolone 1 mg/kg/day (2 weeks) then tapped by 1 mg/week during 2 months	6 months	6 months	Nephrotoxicity, hyperpigmentation
	F/32	Liposuction:	Not applied	• Debridement,	4 months	6 months	Hyperpigmen-

Author/Year	Gender/Age	Liposuction/Fat grafting position	Empiric antibiotics	Treatment regimen	Antibiotic treatment course	Follow-up time	Complications
		Abdomen, flank		dressing changes • AMK (3 weeks) + IPM-cilastatin (3 weeks) + CLR (6 months) • Methylprednisolone 1 mg/kg/day (2 weeks) then tapped by 1 mg/week during 2 months			tation

Abbreviations: AMC: Amoxicillin-clavulanate potassium, AMK: Amikacin, AMP: Ampicillin, AMX: Amoxicillin, AZM: Azithromycin, CFP: Cefoperazone, CFR: Cefadroxil, CIP: Ciprofloxacin, CLI: Clindamycin, CLO: Clofazimine, CLR: Clarithromycin, CXM: Cefuroxime, DAP: Daptomycin, DOX: Doxycycline, EMB: Ethambutol, FLC: Fluconazole, FOX: Cefoxitin, GEN: Gentamicin, INH: Isoniazid, IPM: Imipenem, LEX: Cephalexin, LVX: Levofloxacin, LZD: Linezolid, MIN: Minocyline, MTZ: Metronidazole, MXF: Moxifloxacin, PEN: Penicillin, PZA: pyrazinamide, OMC: Omadacyline, RIF: Rifampicin, SAM: Ampicillin-sulbactam, SXT: Trimethoprim-sulfamethoxazole, TEC: Teicoplanin, TGC: Tigecycline, TZD: Tedizolid, TZP: Piperacillin-tazobactam, VAN: Vancomycin.

** Based on susceptibility testing results*

Despite difficult differential diagnosis, most *M. abscessus*-infected cases after liposuction and autologous fat grafting were not complicated as was shown by the high rate of successful treatments, and uncomplicated regimens, even with long treatment periods. Some cases demanded to change initial antibiotics because of intolerant side effects, high cost, or undetected antibiotic resistance due to no susceptibility testing previously conducted [25, 27, 40, 45]. Time for the antibiotic treatment could last from 4 weeks to 18 months. However, the most frequent of regimens in current reports was 12 months (32.6%). Regimens of 6 months (15.2%), 9 months (6.5%), or 18 months (6.5%) were less frequent. Only 21.7% of cases required a regimen not more than 6 months [11, 20, 22, 24, 42, 43]. In addition to antibiotics, surgical debridement and lesion irritation combined with drainage were recommended.

After *M. abscessus* was identified, most of the authors selected antibiotics with a spectrum covering *M. abscessus* without susceptibility testing results [21, 23, 26, 27, 39]. These antibiotics included doxycycline, macrolides (Azithromycin or Clarithromycin), Amikacin, Linezolid, beta-lactam antibiotics (e.g., Imipenem, Cefoxitin), Fluoroquinolones (Moxifloxacin, Levofloxacin), and Tedizolid. In the meanwhile, susceptibility testing played a critical role in effective regimens in 63.0% of cases. These patients were cured without significant complications [10, 11, 24,

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25, 27, 36-38, 42-45, 47]. Among those, Lee et al. demonstrated the important role of susceptibility testing as it helped to detect Moxifloxacin resistance that caused treatment failure [25]. The author changed the regimen to Amikacin and Imipenem-cilastatin following susceptibility testing results.

Among reported regimens, authors preferred to use a macrolide-based regimen following the recommendation of ATS/IDSA [48]. The macrolide-based triple regimen was the most common which consisted of amikacin, = clarithromycin/azithromycin, and another antibiotic (e.g., linezolid or imipenem). Macrolide-based dual regimen was also widely used. Monotherapy with clarithromycin or amikacin also showed good results in some cases [22, 40]. There were still cases of failure treatment using macrolide-based triple drugs, macrolide-based multiple, or non-macrolide-based triple drugs [10, 40, 45]. This proved that multiple drug regimens did not ensure a successful treatment. The selection of antibiotics and regimens should based on susceptibility testing and the response to antibiotics of the patient.

Common adverse effects caused by oral amikacin include gastrointestinal discomfort, nausea, abnormal liver function, headaches, photophobia, and nephrotoxicity. Linezolid could cause rash, hepatitis, pancytopenia, ototoxicity, or peripheral neuropathy. Azithromycin could cause leukopenia whereas cefoxitin might result in maculopapular rash and leukopenia. Besides, clofazimine might be a cause of hyperpigmentation [10, 20, 24, 27, 36, 40, 41].

Some complicated *M. abscessus*-infected cases requiring special treatment or longer treatment time were reported [10, 36, 40, 42]. Furuya et al. reported a case of unrecovered despite prolonged treatment time (22 months) combined with debridement [40]. Cusumano et al. [10] presented a case of multiple drug resistance with a regimen based on susceptibility testing results, leading to treatment failure. In this report, the patient was prescribed empiric antibiotics without any improvement during 2 weeks of waiting for susceptibility testing results. Then, the first regimen based on the susceptibility testing results did not improve symptoms while new abscesses still developed. Antibiotic regimens were changed many times because the patient was not tolerant to tigecyline and many complications caused by cefoxitin happened. Finally, clofazimine and azithromycin was the last choice after other antibiotics were ineffective and limited source of antibiotics in the hospital. The patient recovered with minor complications.

In addition, Hui et al. [36] noted a case of paradoxical reactions during the treatment based on the susceptibility testing results. In this case, symptoms did not improve after 2 weeks of treatment whereas no bacteria isolated. The authors added a corticosteroid to the regimen that significantly improved the symptoms. This patient recovered well after 18 months of treatment. The benefits of corticosteroids to the treatment of *M. abscessus* after liposuction/autologous fat grafting were

also shown in three cases reported by Tuan et al. [42]. A triple regimen combined with methylprednisolone 1 mg/kg/day then tapped by 1 mg every 2 weeks for 2 months, initiating 3 weeks after antibiotic regimen or immediately combined with antibiotic regimens, resulted in promising results and shortened hospital stay (2 - 4 months). Some mild complications such as hyperpigmentation or bruising at the surgical sites were recorded. The hyperpigmentation could be addressed by 4% hydroquinone cream. These patients were satisfied with the results.

3. CONCLUSIONS

M. abscessus infection is a less common complication but causes troubles in diagnosis because of untypical symptoms and the requirement of many times of cultures. This could lead to treatment failure or improper treatment regimen, long hospital stays, and high costs. The awareness of NTM infection after liposuction/autologous fat grafting could contribute to the timely diagnosis and effective treatment regimen. Samples for diagnosis should be cultured many times before excluding NTM from pathogens. Adhering to the recommendation of surgical site infection prevention by the WHO or CDC could minimize the probability of NTM infection postoperatively. Macrolide-based dual or triple regimens were frequently used and effective against *M. abscessus* infection after liposuction and/or autologous fat grafting. The follow-up time should be long enough because of the high chance of recurrence.

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