COST ANALYSIS AND INFLUENCING FACTORS AMONGST SEVERE BURN PATIENTS

ANALYSE DE COÛT DE PRISE EN CHARGE DES BRÛLÉS GRAVES ET DES FACTEURS L'INFLUENÇANT

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SUMMARY. This study analyzed the structure and determined the factors affecting the cost of treatment of severe burns patients. The results showed that the average total costs for a patient was 3275.9 USD. The daily cost of hospitalization was 113.3 USD, the treatment cost for 1% burn surface area was 109.5 USD with the highest proportion for medication and consumable medical equipment (43.2%), followed by surgery and procedures (30.2%). The treatment costs increased with increasing age, burn extent and deep burn area ($p < .05$) and were significantly higher in the group of patients with inhalation injury, electrical burns and in non-survivors ($p < .01$). Multivariate regression analysis found that burn extent, deep burn area and inhalation injury independently influenced the treatment cost of burn patients.

Keywords: burn, treatment cost, influence factors

RÉSUMÉ. *Cette étude a analysé le coût global de la prise en charge d'un brûlé grave ainsi que les imputations et les paramètres associés aux dépenses. Le coût moyen est de 3 275,9$ (113,3$/ % SB/j). Les médicaments et les consommables représentent 43,2 % du total ; le coût des chirurgies 30,2 %. Le coût augmente avec l'âge, la surface brûlée et la profondeur ($p < 0,05$). Il est significativement plus élevé en cas d'inhalation de fumées, de brûlure électrothermique et en cas de brûlure fatale ($p < 0,01$). En analyse multivariée, la surface brûlée, la profondeur et l'inhalation de fumée sont des facteurs indépendants d'augmentation du coût de traitement.*

Mots-clés: *brûlure, traitement, coût, paramètres d'influence*

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Introduction

In recent years, the treatment of burn patients has made significant progress as a result of advances in comprehensive care, early surgical intervention, fluid resuscitation, nutrition and infectious control.[1,2] However, along with that, the cost of treating burn patients has also significantly increased.[3-5] As a result, determining the cost of treating burn patients is an important tool, with regard to resource allocation, treatment and prevention strategies.[6] Most reports about the costs for burn care were recorded in developed countries.[7] Currently, there is still limited research about factors influencing treatment cost for severe burn patients, especially in developing countries. The objective of this study was to analyze the structure and factors influencing cost of treatment for severe burn patients treated at the Viet Nam National Burn Hospital.

Patients and methods

A retrospective study was conducted on 299 severe burn patients, defined as burn extent ≥20% total body surface area (TBSA), treated at Viet Nam National Burn Hospital from January 1, 2021 to December 31, 2021. Patients hospitalized less than 3 days were excluded from the study. Collection criteria included patient features such as age, gender, health insurance; burn characteristics including causal agent, burn extent, deep burn area, inhalation injury and outcomes (death or survivor); treatment costs including total costs as well as cost details regarding laboratory tests, medication and consumable medical equipment, surgical and procedures intervention, and blood products. Treatment costs were compared according to patient characteristics, burn injury characteristics and patient outcome (survivor or death). Multivariate regression analysis was carried out to identify independent factors affecting the cost of treatment. Data were collected, presented as mean or median (if unstandardized distribution), and analyzed using Stata software version 14.0, with p value <.05 regarded as the significant level.

Results

Of the 299 patients, 71.9% were adult, 79.9% were male and 90.3% had medical insurance. Average burn extent was 31% TBSA with 13.7% of patients suffering inhalation injury. Death rate was recorded at 7.7%. The average total cost of treatment for 1 patient was 3275.9 USD, of which health insurance covered 58.1%. The average treatment cost for 1 day of hospital stay was 113.3 USD and the treatment cost for 1% burn area was 109.5 USD (*Table I*).

Table I - Patient characteristics

Characteristics	Subgroup	N	%
Age	Children	63	21.1
	Adult	215	71.9
	Elderly	21	7
	Average, year	33.07 ± 1.1	
Gender	Male	239	79.9
	Female	60	20.1
Health insurance		270	90.3
Causal agent	Scald	69	23.1
	Flame of heat surface	181	60.5
	Electricity	44	14.7
	Chemical agents	5	1.7
Burn area, %BSA		31 (23-44)	
Deep burn area, %BSA		4 (0-14)	
Inhalation injury		41	13.7
Death		23	7.7
Treatment cost (USD)	Total cost, median	3275.9 (1700.1-7841.9)	
	1 day of treatment	113.3 (77.3-210.1)	
	1% burn surface area	109.5 (60.0-186.8)	

BSA = body surface area; IQR = Interquartile range

In terms of structure, medication and consumable medical equipment accounted for the highest proportion of costs (43.2%), followed by expenses for surgery and procedures (30.2%). The cost for blood products was lowest, accounting for only 1.3% (*Table II*).

Table II - Treatment cost details

Laboratory tests	120.4	3.6
Surgery, procedures	1073.4	30.2
Blood products	48.9	1.3
Medication, consumable medical equipment	1282.6	43.2
Other*	607.3	18.3
Total	3275.9 (100)	100

* Meals, family and optional services

The relationship between patient characteristics, burn features and treatment costs is shown in *Table III*. As can be seen, gender did not significantly affect the cost of treatment. The highest costs were seen in the elderly patients, followed by the adult group. In addition, treatment costs

were significantly higher in patients with inhalation injury (12,204.9 vs. 2862.6 USD; p <.01). Regarding causal agents, the highest treatment costs were recorded in the group of electrical burns, followed by chemical burns (p <.01). Furthermore, costs also remarkably increased along with burn extent and deep burn area (p <.001).

Multivariate regression analysis showed that burn area, deep burn area and inhalation injury are independent factors affecting the cost of treating burn patients. Causal agent and age did not independently affect the cost of burn treatment (*Table IV*).

Table III - Treatment costs by patient characteristics

Age, median	Children (n=63)	2705.8 (1638.7-3756.6)	.04
	Adult (n=219)	3677.0 (1626.7-8244.1)	
	Elderly (n=21)	4442.6 (2543.7-12856.1)	
Gender, median	Male (n=239)	3275.9 (1557.7-6885.9)	.26
	Female (n=60)	3402.1 (2301.8-8816.5)	
Causal agent, median	Scald (n=69)	2104.2 (1237.9-2989.3)	.001
	Flame or heat surface (n=181)	4093.0 (1756.8-8915.9)	
	Electricity (n=44)	4885.2 (3212.9-8840.3)	
	Chemical agents (n=5)	4670.9 (1834.9-10364.6)	
Inhalation injury, median	Yes (n=41)	12,204.9 (6666.9-17650.7)	.001
	No (n=258)	2862.6 (1537.5-5715.7)	
Burn extent, median	20-49% (n=232)	2681.0 (1473.6-4834.8)	.001
	≥50 % TBSA (n=67)	11,204.2 (5972.5-17126.3)	
Deep burn area, median	0-19 % TBSA (n=136)	2156.3 (1174.9-7533.3)	.001
	≥20 % TBSA (n=163)	4342.6 (2830.0-7918.2)	

TBSA = Total body surface area

Table IV - Multivariate regression analysis of factors affecting treatment costs

Age	0.5	.4	.21	-.3÷1.2
Electrical injury	36.5	20.6	.08	-4÷76.9
Burn extent	2.5	.6	.001	1.4÷3.7
Deep burn area	2.8	.6	.001	1.6÷4.1
Inhalation injury	60.8	25.6	.018	10.3÷111
_cons.	-14.8	221.9	.5	-57.8÷28.3

The relationship between outcome and treatment cost is indicated in *Table V*. The costs of laboratory tests, blood products, medication and medical supplies were significantly higher in the non-survival group (p <.05). There was no significant difference in the cost of surgery and procedures between the two groups (p >.05). The costs for daily treatment and the whole course of treatment in dead patients were also significantly higher than those in surviving patients (p <.001).

Discussion

There is no doubt that the cost of burn care is still very high and much higher than that for other diseases or trauma. In high income countries, Willenberg et al. reported the median cost of acute care for trauma patients was 22,448 USD (IQR: 11,819 - 33,701 USD).[8] In European countries, for elderly

Table V - Relationship between outcome and treatment cost (USD)

Cost details	Survivor (n=276)	Death (n=23)	p
Laboratory test, median	112.5 (55.7-222.9)	561.9 (225.4-868.8)	.001
Operation, procedures, median	1046.9 (510.3-1990.2)	1767.6 (450.5-2343.4)	.34
Blood products, median	43.5 (0-137.2)	174.1 (81.3-490.7)	.001
Medicines, medical supplies	1228.5 (589.5-3489.3)	4563.1 (1021.8-11615.4)	.01
Other costs, median	608.0 (359.4-1105.1)	470.8 (147.2-686.4)	.005
Cost/1 day of treatment, median	107.5 (76.2-179.8)	662.4 (409.3-1027.6)	.001
Total cost, median	112.5 (55.7-222.9)	561.9 (225.4-868.8)	.03

trauma patients, a report by Van der Vlegel and coworkers indicated a mean cost of 4710 € per patients during their stay in hospital.[9] For breast cancer, the costs ranged from 11,208 USD to 29,780 USD.[10] Compared with other diseases and injuries, burn patients undergo a longer time of hospitalization and intensive care, with multiple operations and procedures such as necrosis excision, auto- and allo- skin graft, daily dressing change, long mechanical ventilation, expensive local and systemic medication, and expensive consumable medical equipment. Number of excision and autografting procedures increased with burn extent and burn severity.[11-15]

Jeevan et al. in 2014 conducted a study in the UK and found that the total cost per burn patient ranged from 2527.77 to 31,870.95 GBP.[16] In Finland, the average cost per hospital stay was 24,400 USD/1% of deep burn area.[17] For mass burn injuries, Mathew and colleagues analyzed data of 48 patients at Chang Gung Memorial Hospital after the Color Dust explosion in Taiwan and found that the average cost per patient was 50,848 USD.[18]

For daily cost of burn care, studies have reported a variety of results. In Australia, Ahn and Maitz reported the average cost per day of hospital stay to be from 3677.35 to 6263.71 AUD/1% of deep burn area.[19] Patil et al. reported that the daily cost for burn patients in France was 934 USD, in Germany it was 726 USD, and in Hungary it was 280.12 USD.[20]

In the developing world, some studies have reported treatment costs for burn patients, and in general burn care cost was much lower than that in developed countries. For example, in India, Ahuja and Goswami reported the mean treatment cost for burn patients was 1060.52 USD and the average daily treatment cost was 134.96 USD.[21] Another study in Brazil by Anami and colleagues indicated that the average cost of burn care was 39,594.9 USD, the average daily cost was 1330.48 USD.[22] In 2002, a study by Rangraz Jeddi et al. in Iran indicated that the mean cost per patient was 5445.53 USD.[23] In Nepal, Poudel et al. indicated the mean costs were 896.4 USD for partial burn, 1725 USD for mixed partial-deep burn, and 4,227.6 for deep burn. The largest proportion of costs was for surgery, dressings and bed charges.[24] In our study, the treatment cost was 3275.9 USD and was 113.3 USD per one day of hospitalization, meanwhile average cost for 1% burn area was 109.5 USD.

The point of high consensus on the structure of costs for treating burn patients in both developed and developing countries is that the medicine accounts for the highest proportion of costs. Anami and colleagues reported that medication and blood products represented the highest proportion of costs (18,086.09 USD).[22] For mass burn injuries, Mathew and colleagues reported medication fees (11%) to be one of the three highest cost drivers.[18] In recent study, we found that medicines and medical supplies accounted for 43.2% of total cost.

Determining factors affecting health-care costs could help to improve patient management and may reduce costs in the future. Studies also investigated the relationship between the cost of treating burn patients and patient characteristics and burn features. According to Haikonen et al., increased age significantly affects treatment costs as these patients suffer comorbidities, slower wound healing progress, more complications, and longer hospital stay.[17] An analysis by Sahin and colleagues about the relationship between cost and causal agent found that the total cost for electrical burns was highest (2,2501-2.4039 USD), followed by fire (1.3849-1.6523). USD).[25] A study in Iran on 143 severe burn patients also indicated that the cost for electrical burn patients was higher than for the others.[23] In a recent study, treatment costs for patients with electrical burns were highest. Anami et al. analyzed the treatment cost of 180 patients with burn extent over 20% TBSA and found that the cost of treatment increased along with burned surface area and was significantly higher in the patients with inhalation injury.[22] In Taiwan, mass burn patients with burn extent ≥50% TBSA represented 63.8% of the total expenses.[20]

To the best of our knowledge, there have been few reports on multivariate logistic analysis to find out independent factors influencing the cost of burn care. In a recent study, with bivariate analysis, we found that the cost of treating burn patients was significantly higher in older patients, electrical injury, inhalation injury and large burn extent. However, multivariate analysis indicated that age and electrical injury did not independently affect the cost.

Regarding the relationship between outcome and

treatment cost, most studies reported that costs for non-survivors were significantly higher than those for survivors. In our study, the total cost of treatment and the cost of one day of treatment in the death group was higher than that in the survivor group ($p < 0.05$). This result is consistent with some other studies. In the United States, for instance, Holmes et al. in 2008 found that the average cost of treatment for patients who died was three times higher than for survivors (44,136 vs. 13,208 USD).[2] According to Koljonen et al., the cost of treatment for patients who died was twice as high as that of the patients who survived.[26]

Total cost includes direct and indirect expenses. Direct cost is related to hospital costs. Indirect cost, including loss of working days, reflects the burden of burns on society. Most of the current reports were on direct cost, and our study also only mentioned direct cost. In the future it is necessary to conduct studies on both direct and indirect costs for burn patients, as well as the balance between treatment cost and quality of life.[13]

Conclusion

The cost of treating burn patients is still high, with the highest proportion allocated to medication and consumable medical equipment. Higher treatment costs were significantly found for the group of non-survivors. Burn extent, deep burn area and inhalation injury were independent factors affecting the treatment cost of patients with severe burns.

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