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# Gender has no influence on mortality after burn injuries: A 20-year single center study with 839 patients

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ABSTRACT

*Background:* According to the ABSI – Abbreviated Burn Severity Index – women exhibit an increased risk of succumbing to burn injuries. In contrast, following non-thermal trauma, increased mortality has been shown for the male gender. Therefore, the purpose of this study was to evaluate gender-specific differences among burn patients with special regard to burn mortality.

*Methods:* We retrospectively studied 839 patients who were admitted to the Burn Intensive Care Unit (BICU) and underwent surgical treatment between June 1994 and December 2014. In-hospital mortality was the main clinical endpoint. Odds ratios (ORs) were calculated using univariate and multivariate logistic regression models for the association between sex and mortality.

*Results:* In total, we included 530 male and 309 female burn patients. All patients had at least partial-thickness burns and underwent one or more operative procedures. Women were significantly older than men (mean 60.0 years *vs* 46.2 years; $p<0.001$). Despite having smaller injuries (24.6% *vs* 30.3% total body surface area (TBSA); $p<0.001$), burn mortality among women significantly differed from that of men (27.8% vs 21.7%; OR 1.39, $p=0.045$, 95% CI 1.01–1.92). This association, however, did not persist after adjusting for age, %TBSA, inhalation injury and full-thickness burns (OR 1.07, p=0.77, 95% CI 0.68–1.70).

*Conclusions:* Despite increasing research directed at women's health, the assoziation between gender and burn mortality has yielded conflicting results. This study does not support a gender-specific difference in burn mortality in our study population.



*Abbreviations:* ABSI, abbreviated burn severity index; BICU, burn intensive care unit; CI, confidence interval; ICU, intensive care unit; NBR, National Burn Repository; OR, odds ratio; SD, standard deviation; %TBSA, percent total body surface area.

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## 1. Introduction

Despite advances in injury prevention programs and precautionary measures, burn injuries still represent the fourth most common type of trauma following traffic accidents, falls and interpersonal violence [1,2]. In Europe, the annual incidence lies between 2 and 29 per 100.000 individuals [3]. Although the majority of burns are minor, they can also lead to life-threating injuries. Time to hospital admission and pre-existing co-morbidities are only some variables of the list of known risk factors which influence patients' outcome. The following prognostic determinants have been commonly described in the literature: patients' age, burn size and the presence of inhalation injury [4]. These three variables are commonly used in scoring systems, which find broad acceptance to make objective estimates about burn outcome and thereby facilitate and guide treatment decisions in everyday clinics [5].

Gender as a decisive factor in burn mortality was already described in 1982 when the Abbreviated Burn Severity Index (ABSI) was introduced by Tobiasen et al. [6]. The ABSI was the first burn-specific outcome scoring system which incorporated gender in its prediction attributing females a higher likelihood of death compared to similarly injured men. Within constant development in burn care and changes in patients' demographics, it became necessary to re-validate its predictive accuracy. According to Forster et al, the ABSI can be regarded as a valuable model in modern burn medicine but gender was found to be the weakest predictive value compared to other variables [7]. Notably, the most widely used scoring systems like the Revised Baux score and the Boston score do not include gender in their prediction [8,9]. In addition to this, when McGwin et al. compared data from multiple burn centers across the United States gender was not incorporated in their final prediction model [10].

Despite the increasing evidence that gender significantly influences survival in other fields of medicine, as was shown for trauma-hemorrhagic shock or ICU-acquired infections with a more favorable outcome for (especially young) women, studies in burn research have so far shown inconsistent results regarding gender dimorphism in outcome analysis [3,11,12]. Numerous studies confirmed female sex to be a negative predictor in burn outcome, although this association varied markedly from an 1.4 up to 9-fold increase of burn mortality compared with similarly injured men [13–15]. In addition to this, some authors identified gender dimorphism to become most apparent in patients younger than 60 years, or rather at ages when women can be regarded to be premenopausal. These observations generally suggest a hormonal explanation for the increased risk of women to succumbing to burn injuries [16–19]. Other studies, however, identified gender dimorphism to be significant only among the elderly or the pediatric group, which stands in contrast to the results mentioned before [20,21]. There are several investigations which did not show any difference in burn mortality between men and women, neither among the young nor among the elderly population [22–24].

The understanding of how gender affects survival following burn injury is a vital and necessary step towards developing novel therapeutic interventions. Therefore – and due to the fact that there is only a limited amount of data about the relationship between gender and burn outcome in Europe – our aim was to reconsider the influence of gender on survival after burn injuries in a single center study.

## 2. Materials and methods

### 2.1. Study subjects and variables

The Clinical Division of Plastic and Reconstructive Surgery at the Vienna General Hospital, Medical University of Vienna, provides a large burn intensive care unit (BICU) in Austria. We retrospectively studied the medical records of all patients who were admitted and operated at the BICU between June 1994 and December 2014 (n=886). From this number, 47 patients did not meet inclusion criteria because of missing important variables of interest. Patients less than 18 years of age at the time of admission were further excluded. Also, patients who were not primarily admitted to the BICU or did not undergo operative procedures were excluded, thereby leaving 839 patients for inclusion in this study.

The outcome of interest was in-hospital mortality. A computerized database abstracting demographical, injury and outcome data of these patients was generated. Database variables included age, sex, type of burn (fire, scalds, explosions, electrical, chemical and contact burn), burn etiology (occupational, suicidal, domestic and recreational/sports-related), percent total body surface area burned (%TBSA), burn depth, presence of inhalation injury, number of operative procedures, anatomical distribution (head and neck, upper extremity, torso and lower extremity), length of stay and mortality. The %TBSA burned was calculated using the rule of nines and defined as the sum of the partial and full-thickness burns. For the purpose of this study, a deep burn wound was defined as at least deep partial-thickness burn and the need of surgical intervention. The presence of inhalation injury was determined according to the standards of treatment at our department: Each patient with burn trauma in the head and neck region was examined by an ENT specialist for the presence of inhalation injury. We did not examine the need for mechanical ventilation independently. For each patient, the time from injury to death or discharge was calculated.

Before the dataset was frozen for analysis, all data were independently reviewed by two of the authors (IAE, NK), who resolved inconsistencies and data integrity problems.

### 2.2. Institutional review board

The study was approved by the institutional review board of the Medical University of Vienna and the Vienna General Hospital (protocol registration number 1165/2016).

### 2.3. Statistical analysis

Descriptive statistics were used to describe gender-specific differences in patients' demographics and injury characteristics. Means and standard deviations were computed for continuously coded variables, while proportions were used for categorical variables. Group differences between men and

women in demographic or injury characteristics were then analyzed with *chi-square* test and t-test (or the nonparametric equivalents when appropriate). Univariate logistic regression was conducted to identify for independent predictors of death. Results were reported as odds ratios (ORs) and the corresponding 95% confidence intervals (CIs). We further used multivariate logistic regression analysis to adjust for potentially confounding factors including age, inhalation injury, %TBSA and full-thickness burns. These variables were chosen since they are part of the ABSI score and commonly regarded as independent predictors of burn mortality.

To account for changes in gender-specific mortality trends over time, each year of admission was analyzed separately and then grouped into 10-year intervals from 1994 to 2004 and from 2005 to 2014, respectively. In addition, data were stratified by 10-year and 20-year intervals of patients' age to assess for effect modification by age.

All analyses were conducted with IBM SPSS Statistics for Windows, version 21.0 (IBM Corp., Armonk, N.Y., USA). Statistical testing was two-sided and significance was set at $p<0.05$.

## 3. Results

In total, we identified 839 patients who were admitted for acute burn injury and required surgical treatment during our study period. This is an average of approximately 42 patients/year. Table 1 outlines demographic and injury characteristics of the entire study population, as well as according to sex. Approximately two thirds of all patients were males ($n=530$, 63.3%). Female burn victims were generally older compared with male patients (mean 60.0 years *vs* 46.2 years, $p<0.001$) and more often sustained deeper burn injuries (84.5% full-thickness burns among women *vs* 73.1% among males, $p<0.001$). Mean %TBSA among the study population was 28.1% ranging up to a maximum of 98%. There was a significant gender-specific difference in %TBSA with women having smaller burn injuries than men (mean %TBSA in women 24.6% vs 30.3% in males, $p<0.001$). Inhalation injury did not follow a gender-related pattern but was equally distributed among both sexes.

The most common type of burns among our patient population was by flames, followed by scalds and explosion. The vast majority of injuries happened at home or was related to occupation and free time. There was also a gender-related distribution of type of burn and burn etiology ($p<0.001$). Whereas fire and scalds most commonly affected females, burns due to electrical injuries or explosion more often happened among the male cohort. As for burn etiology, injuries which happened at home were more frequent among females, while work-related burns or injures which occurred during recreational time more often affected male patients. Respecting the anatomical distribution of burn injuries men showed highest incidence of burns on the upper and lower extremities whereas a female preponderance was noted for burn injuries of the torso. Head and neck burns did not differ between the two sexes, though. In general, all patients underwent approximately 2.1 operations at our BICU. This number was slightly higher among male burn victims with 2.2 operative procedures compared with 1.9 operations per patient in the female cohort ($p=0.012$). Overall length of stay was slightly shorter for men with an average of 25.6 days compared with women who stayed approximately 28.9 days at our institution. Though, this association did not reach statistical significance ($p=0.151$).

Outcome analysis showed an overall mortality of 24.0% which significantly differed between the two sexes. Female burn patients exhibited an increased risk of mortality

**Table 1 – Demographic and injury characteristics of the entire study population and according to each gender.**

| | All patients (n=839) | Men (n=530) | Women (n=309) | *p* |
|---|---|---|---|---|
| Age, mean (SD) | 51.3 (20.0) | 46.2 (17.8) | 60.0 (20.5) | <0.001 |
| %TBSA, mean (SD) | 28.1 (21.8) | 30.3 (22.9) | 24.6 (19.4) | <0.001 |
| Full-thickness, n (%) | 645 (77.3) | 384 (73.1) | 261 (84.5) | <0.001 |
| Inhalation Injury, n (%) | 203 (24.2) | 135 (25.4) | 68 (22.0) | 0.246 |
| Type of burn, n (%) | | | | <0.001 |
| Fire | 450 (53.6) | 254 (47.9) | 196 (63.4) | |
| Scalds | 150 (17.9) | 78 (14.7) | 72 (23.3) | |
| Electrical | 66 (7.9) | 62 (11.7) | 4 (1.3) | |
| Explosion | 134 (16.0) | 107 (20.2) | 27 (8.7) | |
| Contact burn | 30 (3.6) | 21 (4.0) | 9 (2.9) | |
| Chemical | 9 (1.1) | 8 (1.5) | 1 (0.3) | |
| Burn etiology, n (%) | | | | <0.001 |
| Domestic | 353 (42.1) | 156 (29.4) | 197 (63.8) | |
| Recreational/Sports-related | 131 (15.6) | 95 (17.9) | 36 (11.7) | |
| Occupational | 125 (14.9) | 119 (22.5) | 6 (1.9) | |
| Suicidal | 50 (6.0) | 31 (5.8) | 19 (6.1) | |
| Not given | 180 (21.5) | 129 (24.3) | 51 (16.5) | |
| Nr. of operations, mean (SD) | 2.1 (1.7) | 2.2 (1.8) | 1.9 (1.5) | 0.012 |
| Length of stay, mean (SD) | 26.8 (31.6) | 25.6 (29.7) | 28.9 (34.3) | 0.151 |

%TBSA: total body surface area burned, SD: standard deviation.

compared with the male population (27.8% *vs* 21.7%; OR 1.39, $p=0.045$, 95%CI 1.01–1.92). Among non-survivors, all women (n=86) suffered from full-thickness burns, whereas there were 7 male patients with deep partial-thickness burns only (there was one patient with missing information on burn depth). Further comparisons between male and female non-survivors are shown in Table 2. There was also a significant association between age and mortality. Fig. 1a and b demonstrate the age-dependent increase of burn mortality among both sexes. Univariate logistic regression analysis reconfirmed this relationship and further showed statistical significant associations between mortality and %TBSA, inhalation injury and burn depth (Table 3 and Fig. 2a–d). Following adjustment for potentially confounding factors, the pattern of results persisted for all variables but for sex (OR 1.07, $p=0.77$, 95% CI 0.68–1.70). There was no association between sex and mortality in the multivariate logistic regression analysis of our study population (Table 4). We also performed effect modification assessment by including the interaction term age×sex in our multivariate regression model. The effect of the term was not significant (p=0.36). The effect of sex remained not significant (p=0.43).

When stratified by decade of age, we did not find an increased odds ratio of death between men and women in any age group, neither in unadjusted nor in adjusted analysis (data not shown). Also a gender-specific evaluation of mortality for each year of admission, as well as grouped in 10-year intervals from 1994 to 2004 and 2005 to 2014, respectively, did not show a significant difference in survival between the two sexes (data not shown).

## 4. Discussion

With increasing research directed at women's health, gender-specific differences have also become significant in burn research. Although gender dimorphism in burn outcome was first described in 1982 when the ABSI was developed by Tobiasen et al., there is no general agreement on the potential of gender-specific differences to influence the outcome following thermal injuries [3,6]. Existing literature has shown some inconsistencies in this regard.

Our study focuses on the difference between men and women following burn injuries. The results, however, do not support a relevant gender-specific difference in burn mortality. The higher risk among women was only apparent in the univariate logistic regression analysis but diminished after controlling for potentially confounding factors. In addition to this, we could not identify a gender-specific difference in survival when groups were stratified by patients' age. Therefore, the outcomes of our study stand in contrast to other research in this area which yielded results different from ours as shown as follows [16–19,25]. O'Keefe and colleagues reported an approximately two-fold increase of burn mortality in women compared to men aged 30 to 59 years [17]. In the youngest and oldest age group they could not find any gender dimorphism in burn mortality and gender-specific differences could not be attributed to most obvious reasons like an imbalance of burn severity. A few years later, McGwin et al and Kerby et al. conducted an extended analysis on burn registry data from the United States of America addressing a more precise effect of age on the relationship between gender and mortality [16,18]. These studies revealed gender-specific differences to be most significant in patients aged between 20 and 34 years.

In other fields of medicine, as for traumatic injuries and critically ill patients, a more favorable outcome was shown for (especially young) women [11,12]. However, there are neither clear underlying mechanisms suggested nor experimental data which could serve as an explanation for the reversed association among burn patients. Most commonly discussed causes for the gender dimorphism include anatomical differences in body composition, genetic polymorphism, differences in metabolic response as well as gender-specific alterations in immune function after injury [14,15,23,26,27]. Several studies emphasized sex hormones to be the central mediators in these changes as gender-specific differences were most apparent during the reproductive age of women. In animal studies, some of these differences in immune response were identified to be reversible by administering 17b-estradial to males and in females by performing ovariectomy or administering estrogen receptor antagonist [28]. Although these observations would confirm the concept of hormonal influence, it remains unclear why estrogens generally have protective effects in other diseases and trauma except for burn injuries. In addition to this, there is no clinical study that quantified hormone levels among adult burn patients to provide evidence for this theory apart from experimental data.

As already mentioned by Steinwall et al., most studies which support a female survival disadvantage derive from the United States of America reporting on data from the American National Burn Repository (NBR) [24]. As a consequence, the same source of data brings up similar results [24]. Apart from that, McGwin et al reported about gender dimorphism in burn

**Table 2 – Comparison of injury characteristics between male and female non-survivors.**

| | Men (n=115) | Women (n=86) | *p* |
|---|---|---|---|
| Age, mean (SD) | 53.0 (18.5) | 69.5 (16.2) | <0.001 |
| %TBSA, mean (SD) | 53.0 (23.3) | 37.1 (21.8) | <0.001 |
| Full-thickness[a], n (%) | 107 (93.1) | 86 (100) | 0.019 |
| Inhalation injury, n (%) | 67 (58.3) | 38 (44.2) | 0.048 |
| Nr. of operations, mean (SD) | 2.6 (1.76) | 2.0 (1.25) | 0.012 |

SD: standard deviation

[a] One male patient with missing information on burn depth.

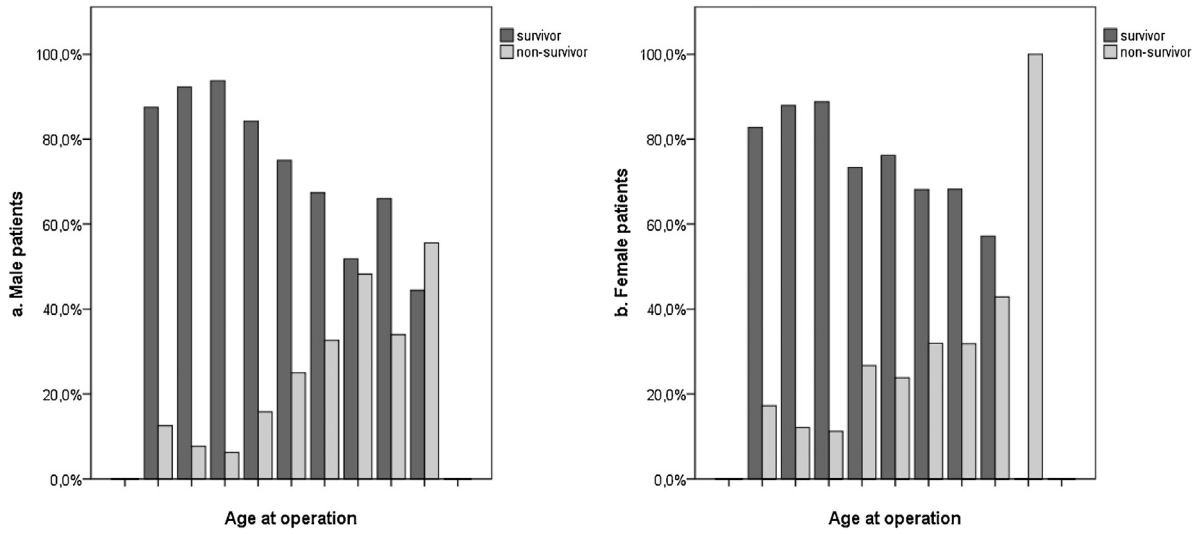


**Fig. 1 – Age-dependent increase of mortality for men (a) and women (b) following burn injuries. Age was grouped into 10-year intervals.**

**Table 3 – Univariate logistic regression analysis identifying variables that influence burn mortality.**

| | OR | 95% CI | *p* |
|---|---|---|---|
| Sex (female) | 1.39 | 1.01-1.92 | 0.045 |
| %TBSA. | 1.05 | 1.04-1.06 | <0.001 |
| Age, years | 1.03 | 1.02-1.04 | <0.001 |
| Full-thickness burn | 11.10 | 5.12-24.06 | <0.001 |
| Inhalation injury | 6.00 | 4.22-8.53 | <0.001 |

patients younger than 60 years in 2001, but some years later gender was not an independent predictor of mortality in their subsequent analysis [10,16]. It is unclear why a female survival disadvantage was found previously but was not shown 7 years after. Probably, the overall reduction of mortality due to better standards of care, might have diminished previous differences by nullifying an unfavorable physiologic factor.

Our data derived from a single center approach granting a homogenous patient population. The overall mortality of our study was slightly higher compared to previously published reports [14,29]. This increase can most likely be attributed to our inclusion criteria, which were limited to adult patients who were exclusively admitted to the intensive care unit (ICU) and underwent surgical intervention. Studies with better rates of survival also included pediatric patients and others from general trauma centers, who were treated conservatively or did not require intensive care medicine [30,31]. The higher mortality in our study compared to Moore et al., who had similar inclusion criteria, can be explained by the increase of mean %TBSA in addition to an older mean age of our population [25]. However, Moore et al. who conducted a multicenter study in Australia and New Zealand showed opposite findings compared to ours regarding gender-specific mortality possibly due to regional differences in burn etiology and treatment options compared to our study which focused on data from Austria.

Approximately two-thirds of our patients were males, which is in accordance with the majority of literature except for a recent validation by Karimi et al. [32]. In their study, women comprised only 18% of the patient cohort [32]. The male predominance in developed countries – especially at young ages – can most likely be explained by the higher exposure to burn injuries in traditionally male occupations, such as fire service or heavy industry [1,33]. In addition to this, epidemiologic reviews showed that accidents with fire and flames mainly occur in the young male population and elderly female population while burn injuries due to scalds are more frequent among children and women [1,3,33]. In our study, we could identify a similar distribution of burn etiology and type of burn between the two sexes. These circumstances might further be responsible for the anatomical distribution in our study. Interestingly, we did not find a gender-specific difference in self-inflicted burns or burns related to interpersonal violence, which can often be attributed for most extensive burns as was shown in other studies [34,35].

With increasing age, the unequal gender distribution seems to decline implicating an increase of burn incidence among women [36]. The fact that life expectancy of women exceeds that of men in addition to an increased likelihood to suffer from co-morbid illness resulting in declined physiologic reserves and resilience– a term which is commonly regarded as frailty–might pose females at an increased risk of sustaining thermal injuries in later life. Likewise, women were significantly older than men in our study. This difference was consistent among survivors as well as non-survivors and might have significantly contributed to the increased risk of death for female burn patients. Due to missing data in this retrospective investigation, however, we could not identify if women had more co-morbidities than men. Length of stay did not differ between the two sexes despite the difference of age.

Since there is no nationwide database on burn injuries, our data are from a single burn unit representing only a proportion of burns in Austria. Yet, one advantage is that the study population is less heterogeneous and we can reduce the difference in treatment strategies and protocols of multicenter studies. Also, we limited our inclusion criteria to severely burned patients as we assumed gender-specific

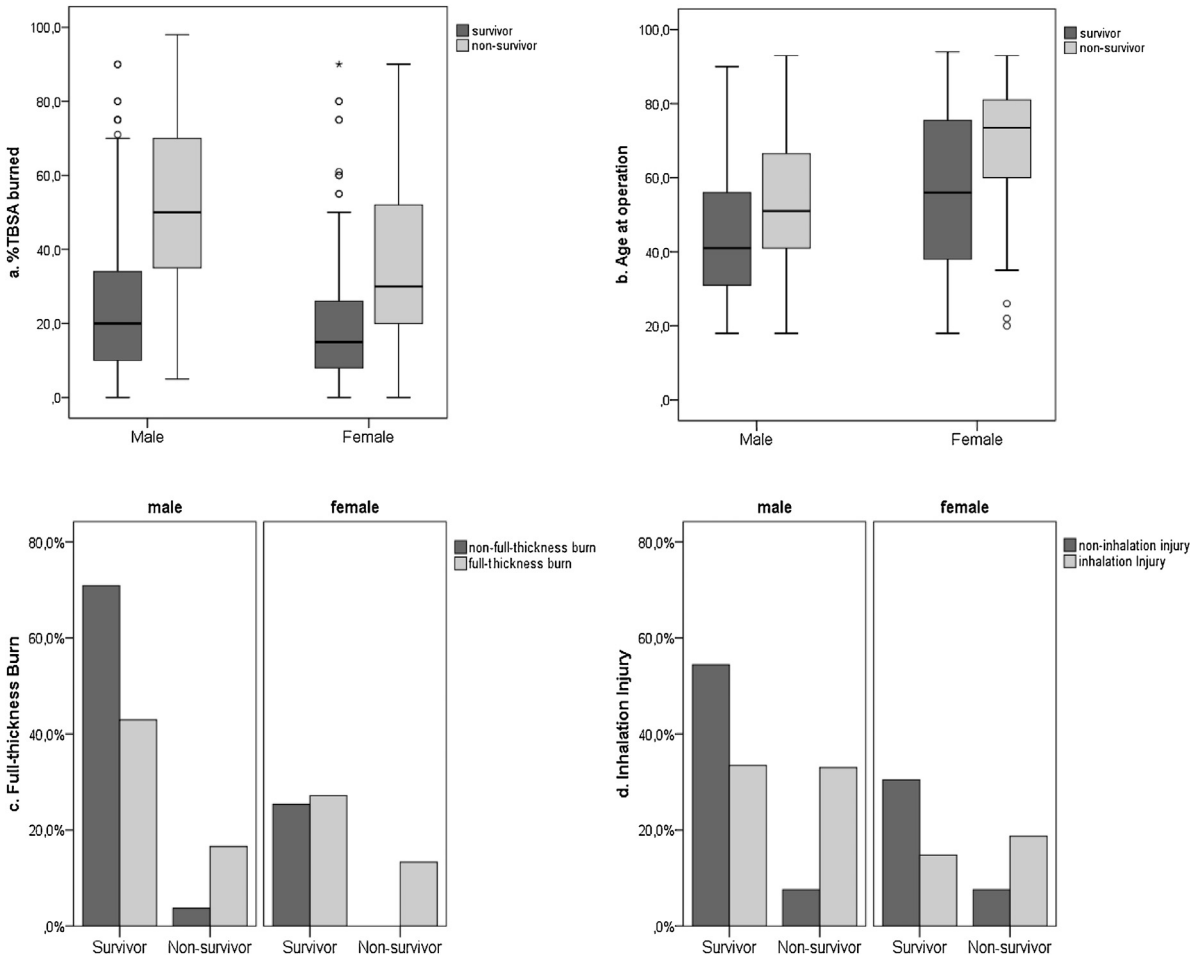


**Fig. 2 – Variables that influence burn mortality according to unadjusted analysis: %TBSA (a), age (b), full-thickness burns (c) and inhalation injury (d).**

**Table 4 – Multivariate logistic regression analysis: variables associated with increased mortality after adjusting for potentially confounding factors.**

| | OR | 95% CI | *p* |
|---|---|---|---|
| Sex (female) | 1.07 | 0.68-1.70 | 0.77 |
| %TBSA. | 1.07 | 1.06-1.09 | <0.001 |
| Age, years | 1.07 | 1.05-1.08 | <0.001 |
| Full-thickness burn | 3.60 | 1.53-8.50 | 0.003 |
| Inhalation injury | 3.21 | 2.04-5.05 | <0.001 |

OR: odds ratio, 95%CI: confidence interval

differences to be most apparent in extensive burn injuries with an increased risk of mortality. Because of the retrospective study design, some data points were inconclusive wherefore we could not evaluate the influence of preexisting medical conditions which may have effected clinical decision-making and survival especially among the elderly population. Similarly to other authors, we could not report on the menopausal status of our female patients since this data is not taken into account in routine documentation. Besides, there was no detailed information on therapeutic modalities to assess the efficacy of early burn surgery for reducing post-burn complications. The latter would have been particularly interesting for further research on gender-specific causes of death. Another limitation is that our study is based on patient records from the past 20 years. Thus, the long study period might not have taken into account improvements in burn care, like fluorescence guided assessment of burn depth in the initial triage process or advanced hydrosurgery for surgical debridement. Although we assure that all patients received the same standards of care irrespectively of their age, gender, ethnicity or socioeconomic status, women had fewer operations than men. In comparison with Chang et al. this is most likely related to the lower %TBSA not implicating a multiple-stage surgical approach [22].

## 5. Conclusion

In our study we found no significant independent effect of gender on the mortality after burn injury. In general, there is no agreement on the debate whether gender influences burn outcome, and if so, to what extent. Existing literature is inconclusive, wherefore this association needs to be reconsidered in a profound investigation in terms of a prospective clinical cohort study which includes data of multiple major

burn centers and considers all possible confounding factors prospectively. If gender-specific differences are shown in this analysis, it would be crucial to identify underlying mechanisms for this association. At the moment, possible reasons remain speculative. This emphasizes the need for further research to draw clear conclusions about the association between gender and burn mortality. Future results must then be incorporated into new therapeutic approaches in order to improve medical standards in this field of medicine.

## Conflicts of interest

All authors declare no conflicts of interest.

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