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Understanding the long-term impacts of burn on the cardiovascular system

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ABSTRACT

Background: Whilst the most obvious impact of burn is on the skin, systemic responses also occur after burn that lead to wide-spread changes to the body, including the heart. The aim of this study was to assess if burn in mid-aged and older adults is associated with increased long-term admissions and death due to diseases of the circulatory system.
Methods: A population-based longitudinal study using linked hospital morbidity and death data from Western Australia was undertaken of adults aged at least 45 years when hospitalized for a first burn ($n = 6004$) in 1980–2012 and a frequency matched non-injury comparison cohort, randomly selected from Western Australia's electoral roll ($n = 22{,}673$). Crude admission rates and cumulative length of stay for circulatory diseases were calculated. Negative binomial and Cox proportional hazards regression modelling were used to generate incidence rate ratios (IRR) and hazard ratios (HR), respectively. HR was used as a measure of the mortality rate ratio (MRR).
Results: After adjustment for demographic factors and pre-existing health status, the burn cohort had 1.46 times (95% confidence interval (CI): 1.36–1.56) as many admissions and almost three times the number of days in hospital with a circulatory system diagnosis (IRR, 95%CI: 2.90, 2.60–3.25) than the uninjured cohort for circulatory diseases. The burn cohort had higher admission rates for ischaemic heart disease (IRR, 95%CI: 1.21, 1.07–1.36), heart failure (IRR, 95%CI: 2.29, 1.85–2.82) and cerebrovascular disease (IRR, 95%CI: 1.57, 1.33–1.84). The burn cohort was found to have increased long-term mortality caused by circulatory system diseases (MRR, 95%CI: 1.11, 1.02–1.20).
Conclusions: Findings of increased hospital admission rates, prolonged length of hospital stay and increased long-term mortality related to circulatory system diseases in the burn cohort provide evidence to support that burn has long-lasting systemic impacts on the heart and circulation.

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1. Background

While the most obvious impact of burn is a visible scar that remains for life, there are hidden impacts of burn that may have long-lasting consequences. The main contributors to adverse outcomes in severely burned patients are the profound metabolic and inflammatory changes that occur in response to the initial injury, which have been shown to persist for at least three years after burn [1]. Increasingly basic scientific and clinical evidence of multiple profound systemic inflammatory responses after burn are being identified, with significant impacts being demonstrated after both minor and severe burns [2–5].

Increased sympathetic activity is a critical part of the acute coordinated response to burns, modulating energy substrate mobilisation, cardiovascular and haemodynamic compensation and contributing to the immune response and healing. Although the short-term activation of these stress response mechanisms is vital, the prolonged duration and increased magnitude of their activity leads to deleterious effects on metabolism, immune function and cardiovascular function [6].

Cardiac stress, mediated by increased catecholamine, is a hallmark of severe burn. It is characterised by marked tachycardia, increased myocardial oxygen consumption, and increased cardiac output, and remains one of the main determinants of survival in large burns [7]. Cardiac stress has been shown to persist for at least two years after burn; however, it is currently unknown how long these conditions persist beyond this phase [1,7]. Myocardial depressant factors are known to be present in burn serum and contribute to burn-generated cardiac contractile dysfunction [8]. However, much of the cellular and molecular mechanism for its role in the development of the cardiac deficiencies remains unknown.

With the advances in medical management of burns and the increasing number of people surviving major injury, studies of the health burden of burn need to include long-term morbidity indicators. Such burden of disease estimates need to be used to support health policy decisions relating to clinical, preventive and health service delivery [9,10]. To date there have been limited studies to investigate long-term health impacts of burn and non-burn injuries. This is in part due to the cost and logistic difficulty in accessing data of large samples of people with follow up over extended periods.

Linked heath administrative data provide the opportunity to explore long-term health impacts in terms of patient hospital care or service needs [11–15]. While limitations of the usefulness of linked administrative data exist, these data provide a cost-effective method to carry out long-term population level research which would otherwise not be possible. Hospitalisations and associated length of hospital stay (LOS) are considered valid measures of disease outcomes and burden [16]. Recent analysis of population-based health administrative data identified increased long-term mortality after both severe and minor burn [17,18]. Given the potential for longer-term impacts of burns on the heart, the aim of this study was to use population-based linked health administrative data to assess if adults 45 years and older surviving a burn have increased longer-term hospital service use for circulatory diseases and mortality caused by circulatory diseases, controlling for demographic factors and pre-existing comorbidities.

2. Methods

This study forms part of the Western Australian Population-based Burn Injury Project – a population-based retrospective cohort study using linked health administrative data provided from the Western Australian Data Linkage System (WADLS). The WADLS is a validated record linkage system that routinely links administrative health data from core datasets (including the Hospital Morbidity Data System and the Western Australia Death Register) for the entire population of Western Australia [13]. Project protocol was approved by the Human Research Ethics Committees of the University of Western Australia and the Western Australian Department of Health.

A de-identified extraction of all linked hospital morbidity (Hospital Morbidity Data System (HMDS)) records for all persons aged 45 years and older admitted to hospital with a first (index) burn in Western Australia, for the period 1 January 1980 to 30 June 2012, was undertaken by WADLS staff. The index burn was defined as the first hospital admission in a patient record set with a burn as the principal and/or additional diagnosis using the International Classification of Diseases (ICD) codes Version 9 (ICD9-CM) 940–949 and Version 10 (ICD10-AM) T20–T31. A population-based comparison cohort was randomly selected from the Western Australian Electoral Roll; any person with an injury hospitalisation during the study period was excluded from this cohort by WADLS. The resultant uninjured comparison cohort was frequency-matched on birth year (4:1) and gender of the burn cases for each year from 1980 to 2012.

Hospital and death data were linked to each cohort (burn, non-injury) for the period 1980–2012. Hospital admissions data included principal and additional diagnoses, external cause of injury, age and gender, Aboriginal status, index admission and separation dates, mode of separation, burn characteristics ((total burns surface area percent – TBSA%), burn depth) and geographic location (census collectors district (~200 households), postcode). Indices of social disadvantage (socio-economic indices for areas (SEIFA) [19]) and remoteness (accessibility remoteness index of Australia (ARIA+) [20]) were supplied for the burn and uninjured cohorts. Mortality data included the date and cause of death, classified using ICD9-CM and ICD10-AM disease and external cause codes. Admissions for diseases of the circulatory system (combined and sub-groups) were identified using principal diagnosis data (refer to Table 1 for ICD codes).

Age was categorised into three groups (45–54, 55–64 and 65+ years) and Aboriginal status was classified by record of Aboriginal or Torres Strait Islander status on any admission record. TBSA% was classified by ICD supplementary codes (948 ICD9CM; T31 ICD10AM) and categorised into three groups: minor burns (TBSA $< 20\%$), severe burns (TBSA $\geq 20\%$), and burns for which TBSA% was unspecified. Comorbidity was assessed using the Charlson Comorbidity Index (CCI) [21] using principal and additional diagnosis fields in the hospital morbidity data with a 5-year look back period [22]. The derived CCI score was then used to classify comorbidity at baseline