CHANGES IN SELECTED BIOCHEMICAL PARAMETERS IN THERMAL BURNS PATIENTS AT THE KORLE BU TEACHING HOSPITAL

BY

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DECLARATION

I, BOAKYE ACHAMPONG KWAKU, author of this dissertation do hereby declare that, with the exception of references to other people's work which has been duly cited, this work has entirely resulted from my personal original research under supervision of Rev. Dr. C. Antwi-Boasiako and Dr. Albert Paintsil and has not been presented for another degree elsewhere.

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DEDICATION

This work is dedicated to the Almighty God and my Senior Pastor of Missionaries of Christ Church Rev. Dr. Charles Antwi-Boasiako for his immense support. Finally, this is dedicated to all my brothers and sisters in the Lord.

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To God be the glory great things he has done. My utmost gratitude goes to God for giving me life, strength, good health and the knowledge to start and complete this work. My very special gratitude go to my able supervisors Rev. Dr. Charles Antwi Boasiako (Head, Department of Physiology, School of Biomedical and Allied Health Sciences), Dr Albert Paintsil (Consultant Plastic Surgeon, Korle Bu Teaching Hospital). I will also appreciate the immense contribution made by Dr. Daniel. A. Antwi (Department of Physiology, School of Biomedical and Allied Health Sciences) and Rev. Emmanuel Frimpong (Department of Physiology, School of Biomedical and Allied Health Sciences).

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LIST OF ABBREVIATIONS

AAS	:	Atomic Absorption Spectrometry
ABA	:	American Burns Association
ADH	:	Anti-diuretic Hormone
AKI	:	Acute Kidney Infection
ANOVA	:	Analysis of Variance
ARDS	:	Adult Respiratory Distress Syndrome
BCG	:	BROMCRESOL GREEN
BP	:	Blood Pressure
°C	:	Degree Celsius
°F	:	Degree Fahrenhiet
CNS	:	Central Nervous System
EDTA	:	Ethylenediaminetetraacetic acid
Fig.	:	Figure
G	:	Gram
GFR	:	Glomerular Filtration Rate
g/dL	:	gram per decilitre
g/L	:	gram per litre

GI	:	Gastrointestinal
HES	:	Hydroxyethyl starch
Hr	:	Hour
KBTH	:	Korle Bu Teaching Hospital
K+	:	Potassium
LASERS	:	Light Amplification Stimulated Emission Radiations
LPG	:	Liquefied Petroleum Gas
LMICs	:	Lower Middle Income Countries
M	:	Mean
mins	:	Minutes
ml	:	Milliliter
mm	:	Millimeter
mmHg	:	Millimeter Of Mercury
MOF	:	Multiple Organ Failure
mmol/l	:	Millimole per Litre
MS	:	Multiscan
Na^+	:	Sodium ion
NRPS & BC	:	National Reconstructive Plastic Surgery and Burns Center

rps	:	Repetitions per second
SD	:	Standard Deviation
SPSS	:	Statistical Package for Social Sciences
SIRS	:	Systemic Inflammatory Response Syndrome
TBI	:	Thermal Burn Injury
TBSA	:	Total Body Surface Area
TP	:	Total protein
WHO	:	World Health Organization

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ABSTRACT

Background: Thermal burns injuries are associated with changes in biochemical parameters which require specialized care. Burn shock is the first consequence of deep and extensive burns that constitutes the main cause of mortality if local and systemic treatments are not correct and timely. Changes in the biochemical parameters are attributed to hyper metabolic state, arising mainly from increases in adrenaline release, hemolysis, sepsis, loss of fluid and electrolytes that requires specialized attention. The serum levels of these biochemical substances such as sodium, potassium, magnesium, albumin, globulin, total proteins, urea and creatinine are very important factors to be observed in thermal burns injury. This is because the serum levels of these parameters are indication of how the body of the patient is responding to the different therapies that are being provided. Determining the changes in these selected biochemical parameters in thermally burnt patients helps in proper and effective management of thermal burn injury that will reduce morbidity and mortality.

General Aim: The aim of this study was to determine changes in selected biochemical parameters in thermally burnt patients who report at the (burn unit) at Korle Bu Teaching Hospital.

Methodology: The study was a case-control longitudinal study involving a total of 106 subjects made up of 53 cases (thermally burnt patients) recruited between the period from September/2015 to April/2016 at the burns center of the Korle Bu Teaching Hospital and 53 age-matched controls. The subjects were classified into 4 groups. The ages of these groups were divided as follows: children (<10 years; n=22); adolescents (10-19 years; n=11); adults (20-45 years; n=16) and middle aged (46- 60 years; n= 4). All these age groups had age-matched controls. Serum electrolyte levels were determined using an Atomic Absorption

Spectrophotometer. Serum total protein, albumin, globulin, urea and creatinine were measured using Vitros 5,1 FS chemistry auto-analyzer. Data collected were entered into SPSS software student version 20.0 and used for analyses.

Results: The children constituted the majority (22)41.1% of the study population followed by the adults (16)30.2% for both cases and controls. The gender distributions were (22)41.5% males and (31)58.5% females for the cases and (36)67.9% had superficial burns whereas (17)32.1% had deep burns. Most of the burn injuries were caused by scalds in (21)39.6% cases followed by gas explosion in (14)26.4% cases and the least (4)7.5% cases caused by contact with hot objects. Serum sodium and magnesium levels were significantly low on ≤ 2, 7th and 14th days post thermal burns in Children ($p<0.001$) ($p=0.001$), Adolescents ($p<0.001$) ($p=0.001$), Adults ($p<0.001$) ($p=0.003$) and Middle aged ($p<0.001$) ($p=0.007$) respectively with ≤ 2 days recording the lowest serum sodium level in all age whereas serum potassium levels were significantly high on ≤ 2, 7th and 14th days post thermal burns in Children ($p=0.020$), Adolescents ($p=0.001$), Adults ($p=0.004$) and Middle aged ($p=0.008$) with ≤ 2 recording the highest serum potassium level in all age groups. The results show that serum urea and creatinine levels were significantly low on ≤ 2, 7th and 14th days post thermal burns in Children ($p=0.010$) ($p=0.001$), Adolescents ($p=0.040$) ($p=0.005$), Adults ($p=0.021$) ($p=0.020$) and Middle aged ($p=0.001$) ($p=0.008$) respectively. The results show that serum total protein, albumin and globulin levels were significantly low on ≤ 2, 7th and 14th days post thermal burns in Children ($p=0.001$) ($p=0.004$) ($p=0.003$), Adolescents ($p<0.001$) ($p=0.003$) ($p=0.009$), Adults ($p=0.002$) ($p=0.007$) ($p=0.002$) and Middle aged ($p=0.001$) ($p=0.009$) ($p=0.004$) with 14^{th} day recording the highest serum total protein level in Children and middle aged groups respectively.

Conclusion: Children and adult had the higher incidence TBIs as compared to the adolescent and the middle-aged age groups. The serum levels of sodium and magnesium were found to be generally low whereas serum potassium levels were high in thermal burnt patients of all ages as compared to controls. Serum albumin, globulin and total proteins were decreased in thermal burnt patients of all ages as compared to controls. Serum urea and creatinine levels were also found to be low in the thermal burnt patients in all age categories. The health team careful monitoring of these biochemical parameters can help improve the health of TBI patients to reduce mortality rate and improve survival.

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Thermal burn injury (TBI) is an injury to the skin caused by intense external sources of heat, such as flames, scalding liquids, or steam that damages or destroys the skin cells and tissue (Al-Muhammadi and Azeez, 2011). This generally happens when the skin makes contact with the heat source. Most burns are caused by carelessness and appear to be preventable, while the rest of the cases are associated with smoking and alcohol intake (Atilla *et al.*, 2015).

Thermal burns is said to be one of the most common and devastating forms of trauma (Church *et al.*, 2006). Thermal burns and related injuries are a major cause of death and disability, especially in subjects under the age of 40 years (Atilla *et al.*, 2015). Even in the developed countries, more than 2 million individuals get seriously burnt annually (Yalcin *et al.*, 2012). The face and hands are the most common sites of TBI, followed by respiratory damage, with eye damage being the least common injury site (Ravindran *et al.*, 2014). Men, especially young men, tend to be more prone to TBI than women (Mirmohammadi *et al.*, 2013). Hot or corrosive substances account for two-thirds of all burns, with fire and flame accounting for one-fourth (Prindeze *et al.*, 2014).

Studies revealed that cardiovascular failures as well as the extent of burn, age and sex are the major determinants of mortality (Ceniceros *et al.*, 2015; Cancio and Wolf, 2012; Marshall *et al.*, 1983). Furthermore, burns patients with failure of 2 or more organ subsystems have about 98%

mortality rate (Marshall *et al.,* 1983), while infection is the major cause in 75% of deaths from burns (Atilla *et al.,* 2015).

In addition, factors that determine the seriousness of a burn injury include the depth, size, and area(s) of involvement, age and general health status of the burn victim (Atilla *et al.,* 2015). Thermal burn injuries are classified as partial-thickness (first or second degree) or full-thickness (third or fourth degree), and the extent of a burn wound is calculated as a percentage of the total body surface area (Martin *et al.*, 2014).

Burn shock is the first consequence of deep and extensive burns that forms the main cause of mortality if local and systemic treatments are not correct and timely (Quazi *et al.,* 2015). Burn shock, is a type of hypovolemic shock in the first stages dominated by disturbances in membrane permeability accompanied by oedema, exudation and evaporation. Secondary manifestations of these processes include plasma loss, haemoconcentration, increased blood viscosity and all hemodynamic consequences that these imply. Without intensive therapy, circulatory shock will follow (Dauti *et.al.,* 1996)

Thermal injury can cause many changes in the skin that elicits local and systemic response (Stiles, 2015). The pathophysiology of the burn syndrome is characterized by the burn wound infection and the host's impaired defense to it, hypermetabolism and increased energy demand. It is well known that a severely burned patient presents major disarrangement of blood homeostasis (Chung *et al.,* 2009; Williams *et al.,* 2009; Brooks *et al.,* 2012). Thermal injury results in massive fluid shifts from the circulating plasma into the interstitial fluid space, causing

hypovolemia and swelling of the burned skin. When burns exceed 25% of Total Body Surface Area (TBSA), there is also edema generation of non injured tissues and organs. Hemo-concentration may become evident in a short time in severe and extensive lesions, but in most patients it becomes apparent for a period from one to three hours after burn injury and if untreated it is usually progressive and over a two day period may even lead to death. The primary reason for the observed effect of the hematocrit increase is the loss of plasma volume into the extracellular space (Brooks *et al.,* 2012). Although most patients face the sepsis period 48 hours after the injury, only a part of them are diagnosed and treated for sepsis and its consequences. Sepsis is a clinical syndrome that complicates severe infection and is characterized by a systemic inflammation and widespread tissue injury. A continuum of severe clinical situations, from sepsis to septic shock and Multiple Organ Failure (MOF) exists.

Threatening post-burn complications are biochemical changes (Arturson, 1996). Any biochemical marker, which can predict poor outcome or complications, will help modify treatment strategies in order to improve outcome and decrease morbidity and mortality in TBIs. An improved understanding of burn pathophysiology in terms of serum biochemical parameters such as serum levels of sodium, potassium, magnesium, albumin, globulin, total proteins, urea and creatinine are very important because their serum levels are pointers as to how the patient is responding to the different therapies that are being provided. Therefore, understanding these levels will contribute to improvement in fluid resuscitation, infection control, support of hypermetabolic response to trauma, nutritional support and early closure of the burn wound and burn outcome in general (Arturson, 1996). Hence, this study was designed to evaluate changes in selected biochemical parameters in acute thermal burn patients at the Korle bu teaching hospital.

1.2 Problem Statement

Thermal burn injury produces substantial biochemical derangements, which contribute to the development of sepsis, multiple organ failure, and death (Abu-Sittah, 2012). Variations in serum electrolytes, proteins and other biochemical substances like urea and creatinine determines the hydro electrolytic and metabolic disturbances are seen in TBI patients. Despite the reported common occurrence of complications during the treatment of TBI, few data exist in literature on the changes in these parameters with insufficient data among the TBI patients. Furthermore, there is inadequate baseline data on these changes to help in patients' management. Since several complications can occur in TBI patients, a prospective study must be undertaken to determine biochemical changes in these patients at the burns unit in the Korle Bu Teaching Hospital.

1.3 Justification

Changes in these selected biochemical parameters in TBI patients if known will help in the proper management of burns patients to reduce morbidity and mortality associated with the complications of this condition. It is for this reason that this study must be carried out at the burns unit at the Korle Bu Teaching hospital. Besides, although the pathophysiology of biochemical parameters dysfunction in burns is increasingly understood, evidence guiding the treatment remains poor and the available methodology is still crude (Przkora *et al.*, 2014**).** There is therefore the need to undertake a prospective study to determine selected biochemical parameters of these patients in Ghana.

1.4 Aim of the study

The aim of this study was to determine selected serum biochemical changes in thermal burns patients at the burns unit of the Korle Bu Teaching hospital.

1.5 Specific Objectives of the study

The objectives of the study were to determine variations in

1. the incidence of TBIs in the various age categories of thermal burns patients
2. selected serum electrolytes such as sodium, potassium and magnesium in thermal burns patients
3. serum albumin, globulin and total proteins in thermal burns patients
4. serum urea and creatinine in thermal burns patients

CHAPTER TWO

LITERATURE REVIEW

2.1 Thermal Burn Injury (TBI)

2.1.1 Definition

Severe thermal injury is defined as burns greater than or equal to over 40% of total body surface area (TBSA) (Perel *et al.,* 2013) is complicated by a profound hypermetabolic response directly proportional to the size of the original injury (Klimeczek *et al.,* 2015). Poorer outcomes from severe burn injury are associated with increased mortality rates, increased rates of infections, and cardiac dysfunction (Hyland and Holland, 2015; Jeschke *et al.,* 2014; Wilmore *et al.,* 2013).

2.2 Epidemiology of TBI

Thermal burn injuries are ranked among the most severe types of injuries suffered by the human body with an attendant high mortality and morbidity rate (Shankar *et al.,* 2014). According to reports by WHO, (2008) TBI is the fourth commonest type of trauma worldwide, following traffic accidents, falls and interpersonal violence. Developing countries have a high incidence of burn injuries, creating a formidable public health problem.

Shinde *et al.,* 2009 reiterated that the socio-economic implications of burns cannot be overemphasized as burn represents an extremely stressful experience for both the burn victims as well as their families. Patients who suffer from extensive burn injuries frequently die, while others suffer from long hospitalization, multiple surgeries, and prolonged rehabilitations. The average burn patient is 24.4 years old and has a mean burn size of 19% of the total body surface area (TBSA) (Alexis *et al.,* 2015). Most burns are caused by carelessness and appear to be

preventable, while the rest of the cases are associated with smoking and alcohol (Atilla *et al.*, 2015). The face and hands are the most common sites of injury, followed by respiratory damage, with eye damage being the least common injury (Ravindran *et al.*, 2014). Men, especially young men, tend to be more prone to burn injury than women (Mirmohammadi *et al.*, 2013).

In the United States, approximately 1.25 million persons are treated annually for burns, 50,000 patients are admitted to hospitals, and 5,500 die from major thermal injury (Rumbach *et al.*, 2013). Fire related burns, apart from causing 6.1/100 000 people deaths each year in Africa, is also among the leading causes of disability-adjusted life years (DALYs) lost in low- and middle-income countries (LMIC) (Peck, 2012; WHO, 2008).

According to Cronin *et al.*, (1996), burns are serious but preventable accidents and without recognition of affecting factors we cannot plan any preventive program. Cronin *et al.*, (1996) posit that high incidence among young adults may be explained by the fact that they are generally active and exposed to hazardous situations both at home and at work. The high incidence of flame burn is explained by use of oil for lamps in villages, candle for lighting, substandard kerosene and gas stoves, use of open coal and wood fires and use of pressure stoves for cooking in urban areas. Open coal or wood fires were the most common source and were responsible for 33.19% total burn cases in India (Cronin *et al.*, 1996). This is consistent with the findings of study in developing countries. On the other hand, the picture reported from industrialized countries differs, where flammable liquids and gas stoves were the most common source of flame burns.

Burns and scalds constitute 5–12% of all traumas and a common problem presented to the health professionals working in hospitals. India shows that 700,000 patients per year are admitted due

to burn but few of them receive attention in specialized burn unit (WHO, 2008). According to Batra, (2003) approximately 90% cases of burn occur in developing world out of which 70% involve children. Persons with the burn injuries greater than 40% TBSA seldom survive in developing world. Batra, (2003) further reports that most incidence of burn takes place most commonly at home because of cooking, availability of inflammable materials, life style and social factors.

Scalds among the children are frequent occurrence at home (WHO, 2006). This pattern suggests certain life style, behavior of individual and age group predisposition to burn. Searching, suspicious nature and lack of knowledge of danger, play some role in burn injury of children while the young adults are burnt because they are in the active part of life to tackle all situations both at home as well as work. Elderly persons are at non-active part of life, therefore not much exposed to the hazardous situations.

Female preponderance in the age group 5-14 and later part of life coincides well with the other studies done in developing countries. Few victims are seen above the age of 56 years, while the largest populations of the burn victim are in the age group 16-25 years, a finding like the study done in India and Jordan (Karimi, 2014).

Prevalence of TBI in Ghana needs a track to see its reflections in studies from different parts of the country. Burden of this phenomenon causes severe pressures on financial and manpower resources (Batra, 2003; Shankar *et al.*, 2014). Therefore, epidemiological studies have an important role in recognition of risk factors and high-risk groups.

Although many studies have documented a progressive improvement in outcome and survival after major burns (Rumbach *et al.*, 2013), management of these patients remains challenging to

all health personnel involved in their care. Improvements in survival have been attributed to the development of the multidisciplinary burn team, an early aggressive surgical approach to major burns, and improved understanding of the pathophysiologic nature of thermal injuries (Periti and Donati, 1995).

2.3 Pathophysiology of TBI

At temperatures, greater than 44 °C (111 °F), proteins begin losing their three dimensional shape and start breaking down (Pallua *et al.*, 2010). This results in cell and tissue damage. Many of the direct health effects of a burn are secondary to disruption in the normal functioning of the skin. They include disruption of the skin's sensation, ability to prevent water loss through evaporation, and ability to control body temperature. Disruption of cell membranes causes cells to lose potassium to the spaces outside the cell and to take up water and sodium (Tintinalli, 2014).

In large burns (over 30% of the total body surface area), there is a significant inflammatory response, this results in increased leakage of fluid from the capillaries and subsequent tissue oedema (Wade, 2013). This causes overall blood volume loss, with the remaining blood suffering significant loss of plasma, making the blood more concentrated. Renal failure and stomach ulcers may result from poor blood flow to organs such as the kidney and the gastrointestinal tract (Donnelly *et al.*, 2012).

The local and systemic inflammatory response to thermal burn injury is extremely complex, resulting in both local burn tissue damage and deleterious systemic effects on all other organ systems distant from the burn area itself. Although the inflammation is initiated almost immediately after the burn injury, the systemic response progresses with time, usually peaking 5 to 7 days after the burn injury (Mazzoleni, 2014; Wilmore *et al.*, 2013; Yalcin *et al.*, 2012).

Much of the local and certainly the majority of the distant changes are caused by inflammatory mediators (Chong *et al.*, 2014; Pierce and Pittet, 2014). TBI initiates systemic inflammatory reactions producing burn toxins and oxygen radicals and finally leads to peroxidation. The relationship between the number of products of oxidative metabolism and natural scavengers of free radicals determines the outcome of local and distant tissue damage and further organ failure in burn injuries (Honnegowda *et al.*, 2015). The injured tissue initiates an inflammation-induced hyperdynamic, hypermetabolic state that can lead to severe progressive distant organ failure (Singh *et al.*, 2013).

2.4 Anatomy of the skin

The skin covers the entire external surface of the human body and is the principal site of interaction with the surrounding world. It serves as a protective barrier that prevents internal tissues from exposure to trauma, ultraviolet (UV) radiation, temperature extremes, toxins, and bacteria. Other important functions include sensory perception, immunologic surveillance, thermoregulation, and control of insensible fluid loss (Carlson *et al.*, 1996).

The integument consists of 2 mutually dependent layers, the epidermis and dermis, which rest on a fatty subcutaneous layer, the panniculus adiposus. The epidermis is derived primarily from surface ectoderm but is colonized by pigment-containing melanocytes of neural crest origin, antigen-processing Langerhans cells of bone marrow origin, and pressure-sensing Merkel cells of neural crest origin. The dermis is derived primarily from mesoderm and contains collagen, elastic fibers, blood vessels, sensory structures, and fibroblasts (Carlson *et al.*, 1996).

2.5 Classification of Burns

Burns can be classified by depth, mechanism of injury, extent, and associated injuries. The most commonly used classification is based on the depth of injury. The depth of a burn is usually determined via examination, although a biopsy may also be used. Tiwari, (2012) posits that it may be difficult to accurately determine the depth of a burn on a single examination and repeated examinations over a few days may be necessary. Based on the depth of injury, burns can be classified as First-degree burn or epithelial burns, Second-degree burns (Second-degree superficial and second degree deep) and Third-degree burn (full thickness burns).

2.5.1 Superficial (First Degree) Burns

This type of burns which affect only the superficial layer of the skin (Epidermis) is described as superficial burn. It appears red without blisters and dry pain. It takes 5–10 days to heal and it heals well. Repeated sunburns increase the risk of skin cancer later in life.

2.5.2 Superficial Partial-Thickness (Second Degree) Burns

Second-degree burns are typically caused by hot water and are always accompanied by blister formation. Second-degree burns are erythromatous, sore, and moist. They are also called dermal partial thickness burns (Hettiaratchy and Papini, 2004). It extends from the epidermis into superficial (papillary) dermis. There is redness with clear blister which blanches with pressure. It is moist and very painful similar to first degree burns. The pain is soothed by cooling. There are minimal or no edema, tingling and hyperesthesia since the nerve endings are present. Healing takes place less than 2–3 weeks with local infection/cellulitis but no scarring typically.

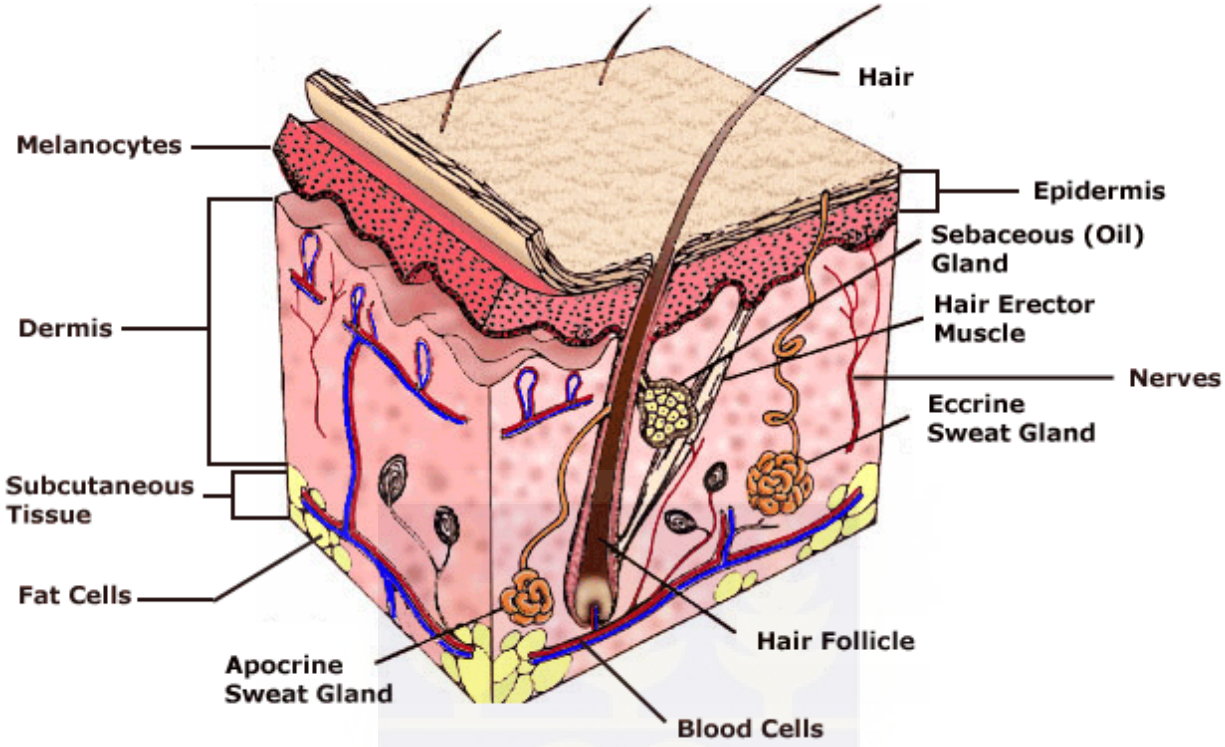

Figure 2.1: Showing a labeled picture of the human skin

2.5.3 Deep Partial-Thickness (Second Degree) Burns

It involves the epidermis, upper dermis, and extends into deep (reticular) dermis. It is like third degree burns and appears yellow or white, less blanching. It may be blistering with mottled red base, broken epidermis, weeping surface and edema but in some instances, dry. Deep dermal burns have immediate blistering, the skin peels off, and the exposed reticular dermis has no capillary refill, the circulation is sluggish and pain sensation is decreased.

Dermal vascular plexus is extensively destroyed. Healing time is over 21 days and hypertrophic scarring is likely. A large, deep second-degree burn requires excision and skin grafting (Rau *et al.,* 2014; Hettiaratchy and Papini 2004; Evers *et al.,* 2010). There is pressure and discomfort,

sensitive to cold air. Recovery is in 3 to 8 weeks, with some scarring and depigmentation, contractures which may require excision. Infection may convert it to full thickness which may prolong hospitalization.

2.5.4 Full Thickness (Third Degree) Burns

This type of burns involves the epidermis, entire dermis and sometimes subcutaneous tissues. They are stiff, pale white or brown with no blanching, very dry, leathery or charred. Sometimes with broken skin with fat exposed and oedema. It is painless; there may be shock, hematuria (blood in the urine) and possibly haemolysis (blood cell destruction). Flame usually causes a third-degree burn. As described by Hettiaratchy and Papini (2004) the burn is deep, impacting all layers of skin and at worst also subcutaneous tissue and muscles. The injured area is dry, leathery, and without sensation as the sensory nerves is destroyed. There is no blister formation and no capillary refill. A third-degree burn does not heal spontaneously but always requires surgery. Scarring is inevitable.

Hyper metabolism develops because of large burns. Energy expenditure, oxygen consumption and carbon dioxide production increase. This leads to increased ventilatory demand and minute ventilation increases. Hemodynamic is typically hyper dynamic; heart rate and cardiac output increase although occasionally myocardial depression may occur. As a sign of systemic inflammatory response hyperthermia may develop. Thermal injury also causes per oxidation of hepatocytes, tubular dysfunction in the kidneys and decreased blood flow to the bowel, pulmonary hypertension and oedema. Catabolic reactions in fat and muscle tissue can be seen (Latenser, 2009). Healing is prolonged (months) and incomplete scarring, contractures, and amputation may result. Early excision is recommended.

2.5.5 Deep Full-Thickness (Fourth Degree) Burns

Deep Full Thickness extends through entire skin and into underlying fat muscle and bone. It appears black or charred with eschar, sloughs may be present. It is dry and painless and has possible entrance and exit wounds in electrical burn. Scarring require excision and skin grafting may be necessary. Contractures and loss of digits or extremity requires amputation, significant functional impairment and, in some cases, death may result.

Hyper metabolism develops because of large burns. Energy expenditure, oxygen consumption and carbon dioxide production increase. This leads to increased ventilatory demand and minute ventilation increases. Hemodynamics is typically hyper dynamic; heart rate and cardiac output increase although occasionally myocardial depression may occur. As a sign of systemic inflammatory response hyperthermia may develop. Thermal injury also causes per oxidation of hepatocytes, tubular dysfunction in the kidneys, and decreased blood flow to the bowel, pulmonary hypertension and oedema. Catabolic reactions in fat and muscle tissue can be seen (Latenser, 2009).

Table 2.1 Classification of Thermal Burn Injuries

Classification	Depth	Clinical features
Superficial thickness	Involves epidermis	Erythema and pain but no blisters
Partial thickness-superficial	Involves papillary dermis	Blisters, clear fluid and pain
Partial thickness-deep	Involves reticular dermis	Whiter appearance, fixed red staining, reduced sensation
Full thickness	Involves epidermis, dermis, and subcutaneous fat	Charred, thrombosed blood vessels, no pain
Subdermal	Involves underlying tissues, such as tendons, muscle, and bone	Charred, dry, brown or white without sensation

(Williams *et al.*, 2009; Singer and Clarke, 1999)

Burn severity is determined through among other things the size of the skin affected. The size of a burn is measured as a percentage the total body surface area (TBSA) affected by partial thickness or full thickness burns. First-degree burns that are only red in color and are not blistering are not included in this estimation. Most first degree burns (70%) involve less than 10% of the TBSA (Tintinalli, 2014).

There are several methods to determine the TBSA, including the ‘‘rule of nines’’, Lund and Browder charts, and estimations based on a person’s palm size.

The rule of nines is easy to remember but only accurate in people over 16 years of age. More accurate estimates can be made using Lund and Browder charts, which consider the different proportions of body parts in adults and children. The size of a person's handprint (including the palm and fingers) is approximately 1% of their TBSA (Herndon, 2012).

2.6 Risk Factors for TBI

Herndon, (2012) sees the presence of a pre-existing impairment, history of a sibling burn, and maternal illiteracy or low education cited as significant risk factors for burns especially in childhood burns. Burn injuries occur more commonly in the poor. Smoking has also been noted as a risk factor, although alcohol use is not. Fire related burns are generally more common in colder climates. Specific risk factors in the developing world include cooking with open fires or on the floor as well as developmental disabilities in children and chronic diseases in adults (Peck, 2012).

In the developed world, adult males have twice the incidence as females from burns. This is probably due to their higher risk occupations and greater risk-taking activities. In many countries in the developing world, however, females have twice the risk of males. This is often related to accidents in the kitchen or domestic violence (Peck, 2012). Children under the age of five, adolescent males and adults over 65 are mostly vulnerable (Peck, 2012).

2.7 Clinical Features of TBI

Superficial burns cause pain lasting two or three days, followed by peeling of the skin over the next few days. Individuals suffering from more severe burns may indicate discomfort or complain of feeling pressure rather than pain (Disseldorp *et al.*, 2013).

Full-thickness burns may be entirely insensitive to light touch or puncture. While superficial burns are typically red in color, severe burns may be pink, white or black (Herndon, 2012). Burns around the mouth or singed hair inside the nose may indicate that burns to the airways have occurred, but these findings are not definitive (Wade, 2013). More worrisome signs include shortness of breath, hoarseness and stridor or wheezing (Wade, 2013).

During the healing process, itchiness is common occurring in up to 90% of adults and nearly all children. Numbness or tingling may persist for a prolonged period after an electrical injury (Goutos *et al.,* 2009). Burns may also produce emotional and psychological distress.

2.8 Impact of TBI

Severe thermal injury is one of the most devastating physical and psychological traumas a person can suffer. Thermal burn patients present with several known suffering and sequels that affect life quality and produce longstanding emotional and social impacts. Majority of the patients experience serious changes in the early stages of burn. These mediating variables include low social support, emotion and avoidant coping styles, and personality traits such as neuroticism and low extraversion, negatively affect adjustment after burn injury.

The impact affects the patient's social interactions, vocational life, as well as their activities of daily living. Approximately 75% of burn cases are mild and treated on an out-patient basis (Sharma, 2007; Forjuoh, 2006).

According to reports by WHO, (2008) Thermal Burns are the fourth most common type of trauma worldwide, following traffic accidents, falls and interpersonal violence. Death by burn injury in low and middle income countries (LMICs) like Ghana is estimated to be eleven times higher than in high-income countries. Over 95% of fire related burns occur in LMICs reported by

Peden, (2008) and Salomon *et al.*, (2013) and are among the leading causes of disability-adjusted life years (DALYs) lost in LMICs (Dissanaike and Rahimi, 2009).

World Health Organization (WHO) estimated that 43,000 people die of burns in Africa every year with a rate of 6.1 per 100,000 (Mock *et al*., 2008). Flames, scalds (including steam) and contact burns are the top three causes of severe burns in most studies (Brusselaers *et al.*, 2010). Albertyn *et al.*, (2006) stated that burn injury is on the increase throughout Africa citing poverty, illiteracy and movement to urban slums and shanty towns as some of the reasons. These occur in regions that generally lack the necessary infrastructure to reduce the incidence and severity of burns (Salomon *et al.*, 2013; Lau, 2006).

2.9 Biochemical parameters in TBI

2.9.1 Serum total protein, albumin and globulin

Studies have reported a decrease in the serum total protein for all age groups for both male and female burn patients in comparison with healthy controls (Al-Muhammadi and Azeez, 2011). That study was supported by Singh *et al.*, 2013 who recorded that marked decreased in plasma proteins occurred during early post burn. Other study also pointed out that burns injury results in dramatic changes in plasma proteins in which the concentration of protein was significantly lower in serum of patient than the control (Bahmani *et al.*, 2014). This is also consistent with Jansson, (2013) who states that there is loss of homeostatic control as a result of massive losses of fluid and protein during the first 24 hours. The massive amount of fluid needed during resuscitation, particularly in larger burns, creates a generalized edema that is caused both by the volume of fluid itself and the decreased colloid osmotic pressure that will develop secondary to the resuscitation fluid given and to proteins lost from the circulation. This may compromise

tissue perfusion in both injured and uninjured tissues of the burn-injured patients. These results occur because local inflammatory cytokines enter the circulation and result in systemic inflammatory response. As burns approach 25% TBSA, this will lead the micro vascular leak to become generalized and permit the loss of fluid and protein from the intravascular compartment to the extravascular compartment and finally they are lost through the wound (Al-Muhammadi and Azeez, 2011).

The results of serum albumin of both males and females for all age groups show significant decrease in comparison with healthy controls (Alkazaz *et al.*, 2014). These results are in agreement with Guo and Xia, 2015 who states that serum albumin concentration decreased gradually after resuscitation.

The study conducted by Alejandra Aguayo-Becerra *et al.*, (2013) showed a highly significant decrease of albumin level in sera of burn patients compared to control group. This result was in line with the fact that skin is the major storage for albumin so whenever the skin got burned the albumin level will decrease. Burns affecting >20% TBSA of the body surface cause a major loss of extracellular fluids, thereby inducing shock by increasing vascular permeability and reducing plasma albumin from the wound exudations (Lehnhardt *et al.*, 2005). The results of that study agreed with Alejandra Aguayo-Becerra *et al.*, (2013) who suggests that hypoalbuminemia has a deleterious effect on patient survival but does have some limitations. Alkazaz *et al.*, (2014) reported a mortality rate of <10% in severely burn patients (2/23) in whom hypoalbuminemia was frequently observed, demonstrating a significant association between the extent of the burn and the serum albumin level.

Globulin level in the study by Alkazaz *et al.,* (2014) showed a highly significant decrease in sera of burn patients compared to control group. This decrease is due to blood loss via damaged skin (Ennis *et al.,* 2008). Alkazaz *et al.,* (2014) result was in agreement with Al-Muhammadi and Azeez, (2011) who found that the total serum protein, albumin and globulin of male and female burn patients show significant decrease.

2.9.2 Serum sodium

The serum sodium of male and female burn patients before resuscitation is reported to be significantly decreased in comparison with healthy control (Al-Muhammadi and Azeez, 2011). These results are consistent with Kumar *et al.,* (2015) who states that during the first 3 days after burn, serum sodium concentrations were moderately elevated in the patients. As well as, these results were supported by Guo and Xia, (2015) who pointed out that serum sodium decreased post-burn and increased after resuscitation. Other study found that the initial resuscitation period below 36 hours characterized by hyponatremia. The explanation for these results are in major burns, intravascular volume is lost in burned and unburned tissues: this process is due to an increase in vascular permeability, increased interstitial osmotic pressure in burn tissue and cellular edema. The most significant shifts occur in the first hours. Hyponatremia is frequent, and the restoration of sodium losses in the burn tissue is therefore essential. While the hypernatremia which will occur later on is caused by several mechanisms: intracellular sodium mobilization, reabsorption of cellular edema, urinary retention of sodium (because of the increase in renin, angiotensin and ADH), and the use of isotonic or hypertonic fluids in the resuscitation phase (Wall and Allorto, 2015).

2.9.3 Serum potassium

Significant increase serum potassium levels for male and female's thermal burns patients before resuscitation has been reported (Al-Muhammadi and Azeez, 2011). This results is supported by other study which states that in major burns, the initial resuscitation period (between 0 and 36 hours) characterized by hyperkalaemia because of the massive tissue necrosis (Wall and Allorto, 2015). As well as, Singh *et al.,* (2013) state that potassium ions will increase if severe hemolysis has occurred or renal impairment is present. Serum potassium levels after resuscitation are also significantly decreased in comparison with healthy control (Al-Muhammadi and Azeez, 2011). This result agrees with Rainer *et al.,* (1999) who pointed out that hypokalaemia is well recognized after stress states and is due to a combination of the effect of adrenaline and insulin. Adrenaline stimulates receptors on skeletal muscle with consequent uptake of potassium from the circulation. It is probable that total body potassium is not reduced. As well as, other study showed that the early post-resuscitation period between 2-6 days of burns patients characterized by hypokalaemia. It may be due to increased potassium losses (Urinary, gastric and fecal) and the intracellular shift of potassium because of the administration of Carbohydrates Rainer *et al.,* (1999).

2.9.4 Serum urea and creatinine

Burns cause a reduction of blood flow to the kidney which lead to, buildup of nitrogen waste products, such as creatinine and urea in the body (azotemia). Prerenal azotemia is the most common form of kidney failure in hospitalized patients (Gupta *et al.,* 2016). Sabry *et al.,* (2009) conclude from their study that acute renal failure complicates burn patients and is related to the size and depth of burn and occurrence of septicemia. A highly significant increase in urea level was observed in sera of burn patients compared to control group Alkazaz *et al.,* (2014).

2.9.5 Serum magnesium

The study by Broughton *et al.,* (1968) showed that hypomagnesemia occurs both early and late in the clinical course of burns and is frequently symptomatic with muscle cramps, tremor, hallucinations, and depression. Another study by Berger *et al.,* (1997) showed that the low magnesium serum concentrations were short lasting, reverting to within normal ranges by day 3. Low serum concentrations were observed during the first 4-5 days and five patients developed a moderate hypomagnesemia during the second and third week after injury. Three factors explain the initial decrease of the serum concentrations: cutaneous losses, urinary losses, and acute hemodilution resulting from the extensive fluid resuscitation volumes required during the first 48 h after injury. The role of magnesium storage, of parathyroid hormone and other hormones involved in bone metabolism, and of intake levels remains unknown. Until recently mild symptom-free hypomagnesemia was not considered to be clinically relevant, but the demonstration of a high frequency of cardiovascular alterations associated with low magnesium concentrations has shown the importance of this cation (Neff *et al.,* 2005; Cernak *et al.,* 2000). Numerous studies support the concept that clinically important morbidity results from extracellular hypomagnesemia, even though circulating magnesium concentrations may not accurately reflect either cellular stores or the active ionized fraction (Pilkington *et al.,* 2012). The absence of increased urinary excretion under such circumstances indirectly reflects a deficiency state. Magnesium and potassium metabolism are linked through their renal excretion. Magnesium is a required cofactor for most ATPases. Deficiency decreases the ATPase activity at the Na-K cellular pump.

2.10 Management of Burns Injury

Management of burn injuries begins right from the very time the burn occurs where pre-hospital care is necessary before admission at the hospital. Subsequently, in-patient provision, application of intravenous fluid, wound care, medication, surgery and other alternative medicines would be taken in the burn management practices.

2.10.1 Pre-hospital Care

The availability, accessibility, affordability, and awareness of pre-hospital and emergency care after burns are crucial determinants between life and death after burn injuries. First-aid respondents, strengthening ambulance services, decreasing the interval between injury and hospital contact, promoting referral system based on triage, availability of facilities in hospitals, and expanding communication networks are key strategies to improve pre-hospital care.

Unfortunately, the absence in most Lower Middle Income Countries (LMICs) of efficient first aid networks, an inefficient culture-specific ambulance service, and improper referrals not based on proper triage result, delays in presentation and hospitalization strongly impact morbidity and mortality secondary to major burn injuries. Burn care in low- and middle-income countries (LMICs) is very dependent on the availability of financial resources, equipment, and expertise.

Forjuoh *et al.,* (1995) reports only 48% of all childhood burns in Ghana are treated at a modern health care facility, of which 68% are treated within 24h post-burn. Lack of knowledge regarding the seriousness of the illness and financial constraints are some of the reasons Forjuoh *et al.,* (1995) cited for the delay in treatment.

To provide optimal burn care to a large population with limited resources, it is imperative to strengthen the existing infrastructure. A few regional burn centers should be developed to provide tertiary management and training to burn care staff.

2.10.2 In-patient Provision for Burn Injuries

Burn service stratification is necessary to optimize access to the appropriate level of expertise and minimize unnecessary travelling by patient and family. Basic burn care provision should be undertaken at district and base hospitals led by general surgeons with burns training. Fluid resuscitation, conservative wound management, blood transfusion, treatment of septicemia and simple skin grafting can be undertaken locally, whereas complex and extensive burns should be treated at regional burn centers which can offer as much as possible high-quality rehabilitation, reconstructive surgery, and other therapies.

Referral guidelines should be drawn up to aid the identification of factors that can make a burn injury complex and suggest the need for early referral to the regional burns center. If it is not possible to keep referred patients at burn centers for six to eight weeks of treatment, they can be discharged after two or three weeks of stabilization. Such patients can then be treated at district hospitals or at home with the help of primary health centers. Thus, primary health centers can act as liaison between burn patients and district hospitals.

The need to target health needs appropriately based on priorities defined locally is increasingly recognized as being of crucial importance. Difficulties faced by practitioners in the developing nations arise primarily from inability to provide the same level of infrastructure, technical support, and resources as in developed countries. Local practitioners should be innovative in adapting available resources and facilities to the needs of their patients while maintaining

minimally acceptable standards. Hospital based management involves resuscitation which begins with the assessment and stabilization of the person's airway, breathing and circulation. If inhalation injury is suspected, early intubation may be required (Granger *et al.,* 2009).

This is followed by care of the burn wound itself. People with extensive burns may be wrapped in clean sheets until they arrive at a hospital. As burn wounds are prone to infection, a tetanus booster shot should be given if an individual has not been immunized within the last five years (Wade, 2013). With major burns, early feeding is important. Hyperbaric oxygenation may be useful in addition to traditional treatments.

2.10.3 Intravenous Fluids

Research by Granger *et al.,* (2009) has recommended boluses of isotonic crystalloid solution for victims with poor tissue perfusion. In children with more than 10-20% TBSA burns, and adults with more than 15% TBSA burns, formal fluid resuscitation and monitoring should follow (Granger *et al.,* 2009). This should begin pre-hospital if possible in those with burns greater than 25% TBSA. The Parkland formula can help determine the volume of intravenous fluids required over the first 24 hours. The formula is based on the affected individual's TBSA and weight. Half of the fluid is to be administered over the first 8 hours, and the remainder given over the following 16 hours. The time frame is calculated from the time at which the burn occurred, and not from the time at which fluid resuscitation was begun (Senarath-Yapa and Enoch, 2009). Children require additional maintenance fluid that includes glucose.

Additionally, those with inhalation injuries require more fluid. While inadequate fluid resuscitation may cause problems, over-resuscitation can also be detrimental. The formulas are only a guide, with infusions ideally tailored to a urinary output of >30 ml/h in adults or >1ml/kg

in children and mean arterial pressure greater than 60 mmHg (Senarath-Yapa and Enoch, 2009). While lactated Ringer's solution is often used, there is no evidence that it is superior to normal saline. Crystalloid fluids appear just as good as colloid fluids, and as colloids are more expensive they are not recommended (Granger *et al.,* 2009). Blood transfusions are rarely required. They are typically only recommended when the hemoglobin level falls below 60-80 g/L (6-8 g/dL) due to the associated risk of complications (Wasiak *et al.,* 2013). Intravenous catheters may be placed through burned skin if needed or intraosseous infusions may be used (Wade, 2013).

The goal of fluid management in major burn injuries is to maintain the tissue perfusion in the early phase of burn shock, in which hypovolemia finally occurs due to steady fluid extravasation from the intravascular compartment (Haberal *et al.,* 2010).

2.10.4 Wound Care

Early cooling (within 30 minutes of the burn) reduces burn depth and pain, but care must be taken as over-cooling can result in hypothermia. It should be performed with cool water 10–25 °C (50.0–77.0 °F) and not ice water as the latter can cause further injury. Chemical burns may require extensive irrigation (Granger *et al.,* 2009). Cleaning with soap and water, scraping of slough, necrotic tissue and or removal of eschar, and application of dressings are important aspects of wound care. If intact blisters are present, it is not clear what should be done with them. Some tentative evidence supports leaving them intact. Second degree burns should be reevaluated after two days (Tintinalli, 2014).

In the management of first and second degree burns, little quality evidence exists to determine which type of dressing should be used. It is reasonable to manage first degree burns without dressings (Wasiak *et al.,* 2013). While topical antibiotics are often recommended, there is little

evidence to support their use (Pallua *et al.*, 2010). The use of Silver sulfadiazine or negative-pressure as a wound therapy has little evidence in wound dressing (Dumville and Munson, 2012).

2.10.5 Medications

Burns can be very painful and a number of different options may be used for managing pain. These include administration of analgesics such as ibuprofen and acetaminophen and opioids such as morphine. Anxiolytics such as Benzodiazepine may also be used as an adjunct to reduce anxiety. To reduce itching in the healing process antihistamines, gentle wound massage, or transcutaneous nerve stimulation may be used (Pallua *et al.*, 2010). Antihistamines, however, are only effective for this purpose in 20% of people (Zachariah *et al.*, 2012).

Intravenous antibiotics are recommended before surgery for those with extensive burns (>60% TBSA). As of 2008, guidelines do not recommend their general use due to concerns regarding antibiotic resistance and high risk of fungal infections (Herndon, 2012). Tentative evidence, however, shows that they may improve survival rates in those with large and severe burns. To prevent or treat anaemia in people with burns Erythropoietin has not been found to be effective (Liodaki *et al.*, 2014). Calcium gluconate is a specific antidote which may be used intravenously and /or topically in burns caused by hydrofluoric acid (Wade, 2013).

2.10.6 Surgery

Jeschke *et al.*, (2014) advises that wounds requiring surgical closure with skin grafts or flaps (typically anything more than a small full thickness burn) should be dealt with as early as possible. Circumferential burns of the limbs or chest may need urgent surgical release of the skin, known as an escharotomy. This is done to treat or prevent problems with distal circulation,

or ventilation. It is uncertain if it is useful for neck or digit burns. Fasciotomies may be required for electrical burns (Orgill and Piccolo, 2009).

2.11 Alternative Medicine

Honey has been used since ancient times to aid wound healing and may be beneficial in first and second degree burns. The use of aloe vera has been criticized for its poor quality (Jull *et al.*, 2008). While it might be beneficial in reducing pain and a review from 2007 found tentative evidence of improved healing times a subsequent review from 2012 did not find improved healing over silver sulfadiazine (Dat *et al.*, 2012).

Traditional medicine is commonly used in the treatment of burns in about one-third of the time in low income countries, which may include applications of eggs, mud, leaves or cow dung (Enkhbaatar *et al.*, 2007). Surgical management is limited in some cases due to insufficient financial resources and availability. There are a number of other methods that may be used in addition to medications to reduce procedural pain and anxiety including: virtual reality therapy, hypnosis and behavioral approaches such as distraction techniques (Herndon, 2012).

2.12 Causes of Death of Burn Patients

The most common cause of death in patients with burns in developed countries is multiple organ failure (Brusselaers *et al.*, 2010; Krishnan *et al.*, 2013). The American Burn Association's registry of the causes of burn mortalities indicates that almost 50% of non-survivors died of organ failure (Finkelstein *et al.*, 2006). Organ dysfunctions are mainly noted in the pulmonary, cardiovascular, renal, hepatic, hematologic, and central nervous systems (Ferreira and Sakr, 2011). Later Lefering *et al.*, (2002), noted the gastrointestinal tract as one of the multiple organ failure (MOF) organs and found that gastrointestinal failure did not have impact on mortality and

CNS damage was impossible to assess in most cases due to need for sedation for mechanical ventilation. With regard to these findings, Lefering *et al.,* (2002) suggested that GI and CNS failure should not be considered in MOF score assessments.

By definition, multiple organ failure (MOF) and systemic inflammatory response syndrome (SIRS) both affect at least three organs. This makes pinpointing the clinical diagnosis of death especially challenging. Severe MOF and severe sepsis are both related to burn size, age, and male sex. Both are related to the length of stay in intensive care and duration of mechanical ventilation (Cumming *et al.,* 2001). Sepsis is a clinical syndrome that complicates severe infection and is characterized by systemic inflammation and widespread tissue injury. MOF is a continuum, with increased physiological derangements in individual organs; it is a process rather than an event (American College of Chest Physicians, 1992). Sepsis is a serious and common consequence of burn trauma although the number of patients dying of septicemia has declined (Bloemsma *et al.,* 2008).

Burns shock and inhalation injury are the main causes of early death (< 48h post-burn) together with acute respiratory distress syndrome (ARDS), pneumonia, liver failure, ischemic bowel, and toxic megacolon, cardiac arrest, and myocardial infarction (Krishnan *et al.*,2013).

2.12.1 Burn Mortality

The outcome of burn patients has improved over the past decades reported by Akerlund *et al.,* (2007) and Krishnan *et al.,* (2013) with currently the overall mortality from burn injuries varying between 1.4% and 18% (Brusselaers *et al.,* 2010). Brusselaers *et al.,* (2010) further declare the factors predicting increased mortality to include contact burns, inhalation injury, age, burn size, and female gender. Mortality is highest during the first week post-trauma. Previously up to 75%

of all burn deaths have occurred with one week of the trauma (Coca *et al.,* 2007). Individual organ failures such as the kidney affect the patient prognosis and raise the mortality to over 60% (Mosier *et al.,* 2010).

However, careful fluid resuscitation and nutritional support, burn wound care and infection control, and pulmonary care are all attributable to better prognosis of the burn patient (Akerlund *et al.,* 2007).

2.12.2 Complications

Throughout most of history, serious burns occupying a large percentage of body surface area were an almost certain death sentence because of subsequent infection. A number of factors such as disruption of the skin barrier, ready availability of bacterial nutrients in the burn milieu, destruction of the vascular supply to the burned skin, and systemic disturbances lead to immunosuppression combined together to make burns particularly susceptible to infection.

In his study, Murphy *et al.,* (2003) established that burn injuries lead to multiple short and long term costs to families, communities, and the nation. The obvious consequences of burns are well known and include pain, infections, scarring wound contractures, amputations, and death, as well as psychological trauma. Hypertrophic scarring for example occurs in almost half of severe burn cases (Spurr and Shakespeare, 1990). Keloid formation is relatively more common among people of African descent. Burn injuries are a major cause of prolonged hospital stays, disfigurement, disability, and death in Africa Region (Alonge and Hyder, 2014). No visible sequelae also can be long lasting.

Research by Alonge and Hyder, (2014) found that hyper metabolic and inflammatory alterations can be in a hyper inflammatory state three years post-burn. Pediatric patients in the United States

(n=977) with burns over 30% of their total body surface were followed for up to three years and compared to a cohort of non-injured children.

The resting energy expenditure, body composition, metabolic markers, cardiac and organ function clearly demonstrated that burns caused profound alterations even several years post-burn-demonstrating marked and prolonged hyper metabolism. Increased hyper metabolism, elevated cortisol, catecholamine, cytokines, and acute phase proteins indicate that burned patients are in a hyper inflammatory state up to three years after the burn injury was sustained (Wade *et al.,* 2013). Even though the metabolic alterations after severe burn injury are similar to any major trauma, they are characterized by responses more extreme and sustained (Jeschke *et al.,* 2014).

Burn injuries often lead to long hospital stays in a retrospective analysis of case notes of 149 children with burns who were presented to Hlabisa Hospital in KwaZulu Natal, South Africa, 59%(88) were admitted Hyder *et al.*, (2004), of them 22%(19) developed wound infections, 6%(5) developed contractures and 23%(20) required a total of 32 surgical procedures, and one died. In Ghana, short term complications as identified by Forjuoh *et al.,* 1995, include infection and septicemia. Eighteen percent of childhood burns led to long-term physical impairment or disability. They include, hypertrophic scarring and Keloid, contractures, amputations, and other disfigurement (Forjuoh *et al.,* 1995).

At Bugando Hospital in Mwanza Tanzania for example, from 1995-1997 while burns were only 2.6% of the injuries that were reported, the case fatality rate which averaged 2.2% for all injury, was 13% for burns (even higher than traumatic amputation at 8.7%), (Rutta, *et al.,* 2001). LMIC hospital care is often plagued by chronic shortage of resources and health care professionals

(Lau, 2006). As in many other LMICs, in Ghana, facilities to provide continuing care, functional and psychological rehabilitation, do not exist.

The victim and their families are left to their own devices to come to terms with sometimes, devastating injuries. Due to genetic factors, accessibility and affordability of hospital treatment, reliance on traditional medicine and high burns infection rates, many of these burns result in keloid scarring or contracture formation, in turn leading to significant physical impairment.

Again, a number of complications may occur, with infections being the first enemy for the burnt patient. In order of frequency, potential complications may include respiratory failure, urinary tract infections, pneumonia and cellulitis. Risk factors for infection include: burns of more than 30% TBSA, full-thickness burns, extremes of age (young or old), or burns involving the legs or perineum (Herndon, 2012). Pneumonia occurs particularly common in those with inhalation injuries (Wade, 2013). Anaemia secondary to full thickness burns of greater than 10% TBSA is common (Granger *et al.*, 2009). Compartment syndrome or rhabdomyolysis seen in electrical burns is as result of muscle breakdown. Deep vein thrombosis is estimated to occur in 6 to 25% of critically ill people (Wade, 2013). The hyper metabolic state that may persist for years after a major burn can result in a decrease in bone density and a loss of muscle mass. Rojas *et al.*, (2012) observed that hyper tropical scars and keloids could form in later days in a burnt patient, particularly in young and dark skinned people.

Children may experience psychological trauma with post-traumatic stress disorder following burn injury (Juckett and Hartman-Adams, 2009). Scarring may also result in a disturbance in body image. Social isolation, extreme poverty and child abandonment are common in the developing world as a result of burns (Peck, 2012).

2.13 Prevention of Burns

Historically, about half of all burns were deemed to be preventable (Herndon, 2012). Many health, agencies, corporations, authorities, and even medical personnel in LMICs consider injury prevention to have a much lower priority than disease prevention. Injury prevention policies and programmes are conspicuously absent and ongoing efforts are crisis-oriented, adhoc, and unscientific in nature.

Herndon (2012) suggests that prevention of burn injuries, based on the epidemiology of burn in developing countries, remains a major way of reducing the current spate of morbidity and mortality and is the only logical solution. This is not easy and is time-consuming but easy or not, there are no options; burns must be prevented. Focusing on burn prevention in LMICs rather than on treatment cannot be overemphasized, owing to a shortage of secondary and tertiary management in these settings.

Adequate preventive measures towards high-risk population groups (under 3years) and a specialized unit for adapted management should be instituted.

Prevention programmes should be directed at behavioral and environmental changes which can be easily adopted into lifestyle. Burn prevention programs have significantly decreased rates of serious burns. Preventive measures include: limiting hot water temperatures, smoke alarms, sprinkler systems, proper construction of buildings, and fire-resistant clothing (Pallua *et al.*, 2010).

Experts recommend setting water heaters below 48.8 °C (119.8 °F). Other measures to prevent scalds include using a thermometer to measure bath water temperatures, and splash guards on stoves (Pallua *et al.*, 2010). While the effect of the regulation of fireworks is unclear, there is

tentative evidence of benefit with recommendations including the limitation of the sale of fireworks to children (Herndon, 2012).

2.14 Controversies in Burn Patient Care

2.14.1 On-scene Care

Allison, (2002) have proved that some on-scene actions help reduce the mortality of the burn patients. These actions include supplying oxygen, starting an intravenous line for analgesia and fluid resuscitation as well as avoiding hypothermia (Singer *et al.,* 2010). Muehlberger *et al.,* (2010) added that obtaining a victim's medical history and detailed information about the burn injury and assessing possible concomitant injuries affect the prognosis and care given to burn victims.

Some other on-scene action including the necessity and indication of intubation on site or during transportation, the amount and quality of fluid resuscitation a pre-hospital estimate of burn size and degree (Mackie *et al.,* 2009), burn wound coverage, and the speed of transport to the trauma center with or without a pre-hospital physician (Eastman *et al.,* 2010) have been found useful but still remain subjects of debate.

2.14.2 Intubation

Inhalation injury causes airway swelling and obstruction. It is vital that patients with inhalation injuries are recognized and intubated at the site of the injury (Mackie *et al.,* 2009). In order to correct hypotension caused by sedation during intubation, fluid resuscitation must be augmented (Cancio *et al.,* 2004). Patients receiving excessive volumes of fluids are at increased risk of

sepsis, adult respiratory distress syndrome (ARDS), pneumonia, multiple organ dysfunction syndrome, and death (Klein *et al.,* 2007).

Intubating all burn patients is not recommended because of risks related to intubation (Mackie *et al.,* 2011), however, not intubating a patient with inhalation injury may lead to airway obstruction (Eastman *et al.,* 2010). Therefore the subject of intubation on site is complex and hotly debated. Mackie *et al.,* (2009) suggest that improving the diagnosis of inhalation injury would benefit the burn patients as unnecessary intubation could be avoided.

2.14.3 Fluid Resuscitation

An effective fluid resuscitation regimen has been one major aspect of modern burn care because it has strongly improved patients survival (Akerlund *et al.,* 2007). The Parkland formula is one widely accepted and well-studied protocol for carrying out fluid resuscitation (Bak *et al.,* 2009). However, there seems to be a trend towards providing increasing amounts of fluids, in excess of the Parkland recommendations, to avoid acute kidney injury during acute burn resuscitation in severely injured burn patients. A number of studies have confirmed that exceeding the Parkland formula may have harmful effects and lead to increased mortality (Klein *et al.,* 2007).

The controversy between the uses of colloids versus crystalloids for fluid resuscitation in burn patients still persists. Fluid resuscitation with crystalloids frequently leads to hypoalbuminemia and it is debated whether this should be corrected by albumin supplementation (Atiyeh *et al.,* 2012). Some studies conclude that patients resuscitated with colloids required less fluid than patients resuscitated with crystalloids Atiyeh *et al.,* (2012), but Perel *et al.,* (2013) have debunked this belief. Colloids can almost completely prevent edema in unburned tissues. Albumin use is also associated with a reduced need for vasopressors and a shorter duration of

mechanical ventilation in burn patients with burns to 20% or more of their total body surface area (Park *et al.,* 2012). Although biological colloids such as albumin or fresh frozen plasma carry a risk of biological disease transmission, they are a better choice than synthetic colloids if colloids must be used (Atiyeh *et al.,* 2012). They claim fresh frozen plasma to be the best colloid solution available for burn patients as it diminishes the coagulopathy risk.

Colloid use may increase bleeding and mortality and increase in lung edema. Hydroxyethylstarch (HES) has proven to be an especially harmful colloid for critically ill patients. Large studies have proven HES to increase the risk of AKI, renal replacement therapy, acute liver injury, and death compared to crystalloids (Nisula, 2014).

In 2008, the American Burn Association recommended that crystalloid-based resuscitation be used during the first 24 hours (Endorf and Dries, 2011). As colloids are more expensive than crystalloids and do not improve survival, the use of colloids is not justified (Bayer *et al.,* 2012; Perel *et al.,* 2013; Kallinen, 2013).

CHAPTER THREE

METHODOLOGY

3.1 Study design

This study was a case-control longitudinal study using a convenient and systematic sampling technique.

3.2 Study sites

The study was conducted at the Korle Bu Teaching Hospital in the Greater Accra Region. The hospital is the largest referral hospital in Ghana. Recruitment of participants and blood sampling were carried out at the Burn Wards of the National Reconstructive Plastic Surgery and Burns Centre (NRPS & BC). This NRPS & BC is a sixty-eight (68) bed capacity unit commissioned in May, 1997. It is the Center of its kind and status in West Africa and it receives patients from Ghana and the sub-region.

The Burn unit serves to provide specialized care for acute burn patients until discharge. The samples were analyzed at the Central Laboratory department of the Korle Bu Teaching Hospital.

3.3 Study population

All acute thermal burns patients admitted at the Burn wards of the NRPS & BC of the Korle Bu Teaching Hospital who fulfilled the inclusion criteria and consented to participate in the study during the period of the study from September/ 2015 to April/ 2016 Subjects were recruited based on the following inclusion and exclusion criteria:

3.3.1 Inclusion criteria

Participants were recruited if the following criteria were met:

Severe Thermal burn injury assessed and diagnosed by a specialist Plastic surgeon using the Lund Browder chart.

1. Adult patients who sustained 20% to 60% TBSA burn.
2. Children with 15% to 60% TBSA burn.
3. Burn duration of less than 24 hours.

3.3.2 Exclusion criteria

Participants were excluded from the study based on the following:

1. Burn Patients with human immunodeficiency virus infection.
2. Burn Patients in other immunosuppressive states, hepatitis B or C.
3. Burn Patients with history of diabetes mellitus.
4. Patients with cardiovascular diseases such as hypertension.

3.4 Sample size determination

The minimum sample size was determined by the use of software from: http://sampsize.sourceforge.net/iface/s3.

With the following values:

Minimum Odds Ratio to detect = 2

Percentage exposed among controls=40%

Power=80

Number of controls per case=1

Alpha risk=5%

1:1 matched study design

The minimum sample size of 106 subjects made up of 53 cases and 53 controls.

3.5 Sampling Technique

A convenient and systematic sampling method was used to get eligible participants into the superficial and deep burn groups by clinical diagnosis from the Lund and Browder chart.

3.6 Procedures for Data Collection

Participants were informed about the study through verbal invitations at the Burn Female Ward, burn Male Ward and Burn Children Ward of Korle Bu Teaching Hospital. A written informed consent was obtained from the participants. Eligible participants who consented to participate in the study were made to complete a clinical survey form. This provided information on their biodata, details of burn injury, brief history of injury, pre-injury state and pre-injury conditions.

3.6.1 Participants demographics

The genotype, nationality, tribe, sex, age and occupation of all the participants will be obtained through the administration of questionnaires. The questionnaire for patient baseline demographics and clinical information was pretested with participants (10 patients and 10 controls) at the burns unit.

3.6.2 Collection of blood samples, preparation and storage

The method as described in the Standard Operating Procedure for performing venipuncture in the National Blood Bank (Korle bu) by Ampofo *et al.*, (2002) was used for both patients and controls. Venous blood samples were collected from the patients into two groups of labeled tubes; the first tubes contained EDTA as anti-coagulants to prevent clotting of blood to be used for hematological studies. The second group tubes were without anti-coagulant as plain tubes, for blood used for preparing sera for subsequent biochemical tests.

Rubber tourniquet was tied to the biceps about 8cm above the elbow joint for less than a minute and the site to be punctured cleansed with methylated spirit. Then 5mls of blood was drawn from the brachial vein with a 19G hypodermic needle fixed on 5mls syringe. All asceptic conditions were adhered to. The blood sample was immediately divided into the plain tubes (2.5mls) and the EDTA tubes (2.5mls) and the blood was mixed in the bottles to prevent clotting by gently inverting the tubes four times manually. Aliquots of 2.5mls of each blood sample was transferred into labeled test tubes (13×100mm) and spun immediately after collection in a centrifuge at a speed of 2500rps for 10mins to separate serum from cells. The serum was drawn from the test tube with a micropipette into labeled eppendorf tube; labeled appropriately and stored in a refrigerator at a temperature of -80˚C for biochemical analysis.

3.6.3 Estimation of Biochemical studies

3.6.3.1 Estimation of serum magnesium

Serum magnesium level was measured using a Flame Atomic Absorption Spectrometer (Variant 240FS manufactured by VARIAN Australia Pty Ltd) at the Chemistry Unit of the Ghana Atomic Energy Commission.

Principle

Atomic Absorption Spectrometry (AAS) is a technique for measuring quantities of chemical elements present in environmental samples by measuring the absorbed radiation by the chemical element of interest. This is done by reading the spectra produced when the sample is excited by radiation. The atoms absorb ultraviolet or visible light and make transitions to higher energy levels. Atomic absorption methods measure the amount of energy in the form of photons of light that are absorbed by the sample (Garcia and Baez, 2012).

Procedure

Serum was then treated with nitric acid and Hydrogen peroxide in a microwave digester (ETHOS 900 Model, manufactured by Milestone lab vision scientific instrumental company) to prepare sample for magnesium levels determination. Magnesium level was determined using the manufacturer manual with publication number 85-100009-00.

3.6.3.2 Estimation of serum sodium

Sodium (Na+) quantitatively measured using VITROS 250/350/950/5,1 FS and 4600 Chemistry Systems and the VITROS 5600 Integrated System at the Central Laboratory Unit, KBTH.

Principle and procedure

The VITROS Na+ Slide method is performed using the VITROS Na+ Slides and the VITROS Chemistry Products Calibrator Kit 2 on VITROS 250/350/950/5,1 FS and 4600 Chemistry Systems and the VITROS 5600 Integrated System. The VITROS Na+ Slide is a multilayered, analytical element coated on a polyester support that uses direct potentiometry 2 for measurement of sodium ions. The slide consists of two ion-selective electrodes, each containing methyl monensin (an ionophore for sodium), a reference layer, and a silver layer and a silver

chloride layer coated on a polyester support. A drop of patient sample and a drop of VITROS Reference Fluid on separate halves of the slide results in migration of both fluids toward the center of the paper bridge. A stable liquid junction is formed that connects the reference electrode to the sample electrode. Each electrode produces an electrochemical potential in response to the activity of sodium. The potential difference between the two electrodes is proportional to the sodium concentration in the sample.

3.6.3.3 Estimation of serum potassium

Serum potassium was measured using VITROS 250/350/950/5,1 FS and 4600 Chemistry Systems and the VITROS 5600 Integrated System at the Central Laboratory Unit, KBTH.

Principle and procedure:

The VITROS K+ Slide method is performed using the VITROS K+ Slides and the VITROS Chemistry Products Calibrator Kit 2 on VITROS 250/350/950/5,1 FS and 4600 Chemistry Systems and the VITROS 5600 Integrated System. The VITROS K+ Slide is a multilayered, analytical element coated on a polyester support that uses direct potentiometry for measurement of ionic potassium. The slide consists of two ion selective electrodes, each containing valinomycin (an ionophore for potassium), a reference layer, silver and a silver chloride layer coated on a polyester support. A drop of patient sample and a drop of VITROS Reference Fluid on separate halves of the slide results in migration of both fluids toward the center of the paper bridge. A stable liquid junction is formed connecting the reference electrode to the sample indicator electrode. Each electrode produces an electrical potential in response to the activity of potassium applied to it. The potential difference poised between the two electrodes is proportional to the potassium concentration in the sample.

3.6.3.4 Estimation of serum urea

Serum urea was quantitatively measured using VITROS 250/350/950/5,1 FS and 4600 Chemistry Systems and the VITROS 5600 Integrated System at the Central Laboratory Unit, KBTH.

Principle and procedure:

The VITROS BUN/UREA Slide method is performed using the VITROS BUN/UREA Slides and the VITROS Chemistry Products Calibrator Kit 1 on VITROS 250/350/950/5,1 FS and 4600 Chemistry Systems and the VITROS 5600 Integrated System. The VITROS BUN/UREA Slide is a multilayered, analytical element coated on a polyester support.

A drop of patient sample is deposited on the slide and is evenly distributed by the spreading layer to the underlying layers. Water and non proteinaceous components then travel to the underlying reagent layer, where the urease reaction generates ammonia. The semipermeable membrane allows only ammonia to pass through to the color-forming layer, where it reacts with the indicator to form a dye. The reflection density of the dye is measured and is proportional to the concentration of urea in the sample.

3.6.3.5 Estimation of serum creatinine

Serum creatinine was quantitatively measured using VITROS 250/350/950/5,1 FS and 4600 Chemistry Systems and the VITROS 5600 Integrated System at the Central Laboratory Unit, KBTH.

Principle and procedure

The VITROS CREA Slide method is performed using the VITROS CREA Slides and the VITROS Chemistry Products Calibrator Kit 1 on VITROS 250/350/950/5,1 FS and 4600 Chemistry Systems and the VITROS 5600 Integrated System. The VITROS CREA Slide is a

multilayered, analytical element coated on a polyester support. A drop of patient sample is deposited on the slide and is evenly distributed by the spreading layer to the underlying layers. Creatinine diffuses to the reagent layer, where it is hydrolyzed to creatine in the rate-determining step. The creatine is converted to sarcosine and urea by creatine amidinohydrolase. The sarcosine, in the presence of sarcosine oxidase, is oxidized to glycine, formaldehyde, and hydrogen peroxide. The final reaction involves the peroxidase-catalyzed oxidation of a leuco dye to produce a colored product. Following addition of the sample, the slide is incubated. During the initial reaction phase, endogenous creatine in the sample is oxidized. The resulting change in reflection density is measured at 2 time points. The difference in reflection density is proportional to the concentration of creatinine present in the sample.

3.6.3.6 Estimation of serum total protein

Serum total protein quantitatively measured using VITROS 250/350/950/5,1 FS and 4600 Chemistry Systems and the VITROS 5600 Integrated System at the Central Laboratory Unit, KBTH.

Principle and procedure

The VITROS TP Slide method is performed using the VITROS TP Slides and the VITROS Chemistry Products Calibrator Kit 4 on VITROS 250/350/950/5,1 FS and 4600 Chemistry Systems and the VITROS 5600 Integrated System. The VITROS TP Slide is a multilayered, analytical element coated on a polyester support. The method of analysis is based on the biuret reaction (Kingsley, 1942), which produces a violet complex when protein reacts with cupric ion (Cu+2) in an alkaline medium.

A drop of patient sample is deposited on the slide and is evenly distributed by the spreading layer to the underlying layers. When the fluid penetrates the reagent layer, the reagent diffuses up to

the spreading layer and reacts with protein. The reaction between protein and copper tartrate takes place largely in the spreading layer where the protein is confined because of its high molecular weight.

The amount of colored complex formed is proportional to the amount of total protein in the sample and is measured by reflectance spectrophotometry.

3.6.3.7 Estimation of the serum albumin

Serum albumin was quantitatively measured using VITROS 250/350/950/5,1 FS and 4600 Chemistry Systems and the VITROS 5600 Integrated System at the Central Laboratory Unit, KBTH.

Principle and procedure

The VITROS ALB Slide method is performed using the VITROS ALB Slides and the VITROS Chemistry Products Calibrator Kit 4 on VITROS 250/350/950/5,1 FS and 4600 Chemistry Systems and the VITROS 5600 Integrated System.

The VITROS ALB Slide is a multilayered, analytical element coated on a polyester support.

A drop of patient sample is deposited on the slide and is evenly distributed by the spreading layer to the underlying layers.

When the fluid penetrates the reagent layer, the bromcresol green (BCG) dye diffuses to the spreading layer and binds to albumin from the sample. This binding results in a shift in wavelength of the reflectance maximum of the free dye. The color complex that forms is measured by reflectance spectrophotometry. The amount of albumin-bound dye is proportional to the concentration of albumin in the sample.

3.6.3.8 Estimation of serum globulin

The total globulin fraction was generally determined by subtracting the albumin level from the total protein.

3.7 Data analysis

All values were expressed as mean (M) ± standard deviation (SD) (M±SD). The differences between two means were analyzed statistically using Student's t-test for paired data. Analysis of variance (ANOVA) was used to compare the difference between more than two means of groups of subjects. Statistical significance was defined as p value ≤ 0.05. Data were entered and analyzed using SPSS version 20.0 software.

CHAPTER FOUR

RESULTS

4.1 Characteristics of Study Participants

A total of 106 subjects were sampled. This was made up of 53 thermal burnt patients. This included 22(41.5%) males and 31(58.5%) females. The ages ranged from 1 to 60 years. The subjects were made up of 22(41.1%) children (11(50%) males and 11(50%) female) of age range < 10 years, 11(20.8%) adolescents (4(36%) males and 7(64%) females) of age range 10 to 19 years old, 16(30.2%) adults (5(31%) males and 11(69%) females) of age range 20 to 45 years old and 4(7.9%) middle-aged (1(25%) males and 3(75%) females) of age range 46 to 60 years. There were 53 age-matched controls as well. With regard to age distribution, participants who were <10 years constituted majority 22(41.1%) of the study population followed by the adults with age group 20-45 represented by 16(30.2%). The results showed that 36(67.9%) of the participants had superficial burn whereas 17(32.1%) had deep burns. The results also showed that burn injuries were caused by scalds in 21(39.6%) cases which was followed by gas explosion in 14(26.4%) cases and the least 4(7.5%) cases caused by contact with hot objects. The details of characteristics of study participants between superficial and deep burn injuries are presented in Table 4.1.

Table 4.1 Characteristics of the study population

General Characteristics	Superficial Burn n(%)	Deep Burn n(%)
Age (years)		
1-9	15(41.7)	7(41.2)
10-19	6(16.7)	5(29.4)
20-45	13(36.1)	3(17.6)
46-60	2(5.6)	2(11.8)
Burn depth n(%)	36(67.9)	17(32.1)
Burn Etiology		
Open flame	5(13.9)	2(11.8)
Scald	16(44.4)	4(23.5)
Gas explosion	9(25.0)	6(35.3)
Petroleum ignition	4(11.1)	3(17.6)
Contact with hot objects	2(5.6)	2(5.9)

n = number of participants

% = percentage

4.2 Comparison of serum sodium levels among thermal burn patients on ≤ 2, 7th and 14th days of the various age groups; children, adolescents, adults and middle aged to their respective controls

In a multiple comparison of serum sodium levels for patients on ≤ 2, 7th and 14th days between post thermal burns and controls, the results show that serum sodium levels were significantly low on ≤ 2, 7th and 14th days post thermal burns in Children ($p<0.001$), Adolescents ($p<0.001$), Adults ($p<0.001$) and Middle aged ($p<0.001$) with ≤ 2 recording the lowest serum sodium level in all age groups. The serum sodium levels rose significantly high for the children, Adults and Middle aged on the 7th and the 14th post burns days ($p = 0.004, 0.002$), ($p < 0.001, 0.003$), ($p = 0.001, 0.002$). However, in the adolescents there was a further significant decrease in serum sodium level on the 7th day of post burns ($p < 0.001$) and increased significantly on the 14th day ($p=0.002$).

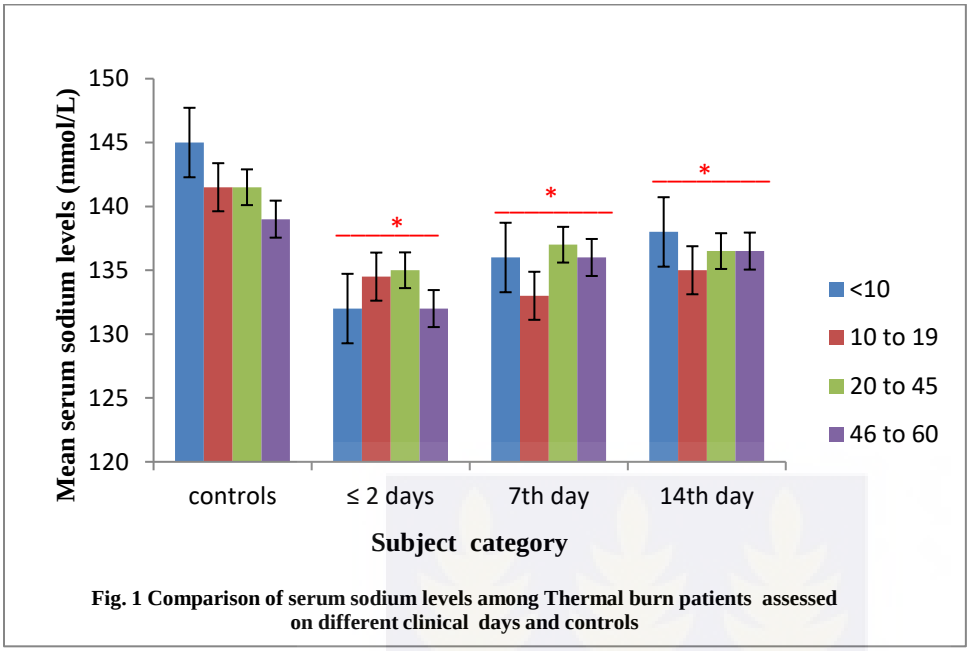

Fig. 1 Comparison of serum sodium levels among Thermal burn patients assessed on different clinical days and controls

* indicates significant difference between control and thermal burns study groups

- <10 indicates children
- 10 to 19 indicates adolescent
- 20 to 45 indicates adults
- 46 to 60 indicates middle-aged

4.3 Comparison of serum potassium levels among thermal burn patients on ≤ 2, 7th and 14th days of the various age groups; children, adolescents, adults and middle aged to their respective controls

Figure 2 shows serum potassium levels for patients on ≤ 2, 7th and 14th days post thermal burns and controls, the results show that serum potassium levels were significantly high on ≤ 2, 7th and 14th days post thermal burns in Children (p= 0.020), Adolescents (p=0.001), Adults (p=0.004) and Middle aged (p=0.008) with the level recorded on ≤ 2 being the highest serum potassium level in all age groups (Fig. 2). The serum potassium levels declined significantly low for the children, Adolescent and Adult on the 7th and the 14th post burns days (p =0.004) (p =0.030), (p=0.001) as shown below. However, in the middle aged there was a further significant decrease in serum potassium level on the 7th day of post burns (p =0.002) and increased significantly on the 14th day (p<0.001) (Fig. 2).

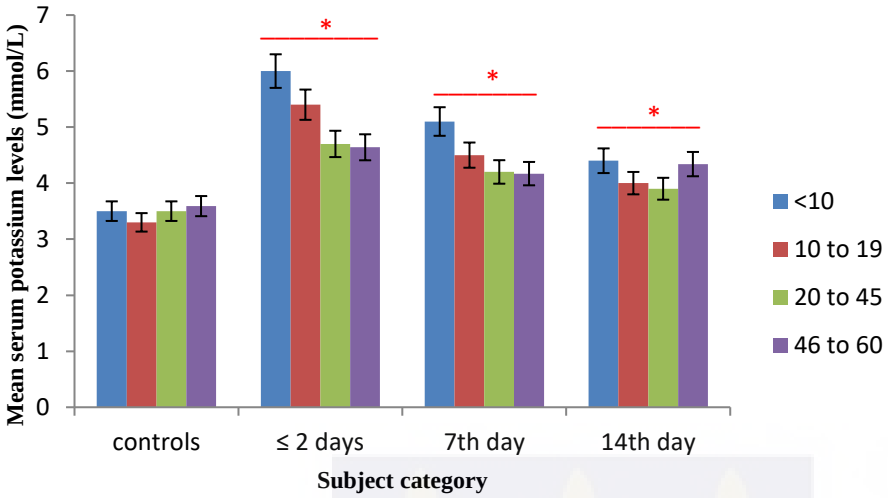

Fig. 2 Comparison of serum potassium levels among thermal burn patients assessed on different clinical days and controls

* indicates significant difference between control and thermal burns study groups

- <10 indicates children
- 10 to 19 indicates adolescent
- 20 to 45 indicates adults
- 46 to 60 indicates middle-aged

4.4 Comparison of serum magnesium levels among thermal burn patients on ≤ 2, 7th and 14th days of the various age groups; children, adolescents, adults and middle aged to their respective controls

The results revealed that the serum magnesium levels for patients on ≤ 2, 7th and 14th days post thermal burns and controls, the results show that serum magnesium levels were significantly low on ≤ 2, 7th and 14th days post thermal burns in Children (p =0.001), Adolescents (p =0.001), Adults (p =0.003) and Middle aged (p =0.007) with ≤ 2 recording the lowest serum magnesium level in all age groups (Fig. 3). The serum magnesium levels rose significantly high for the age groups on the 7th and the 14th post burns days (p =0.002), (p =0.006), (p =0.002) as shown below. However, in the adults there was no further significant rise in serum magnesium level on the ≤ 2 day of post burns (p =0.007) and the 7th day (p=0.010) (Fig. 3).

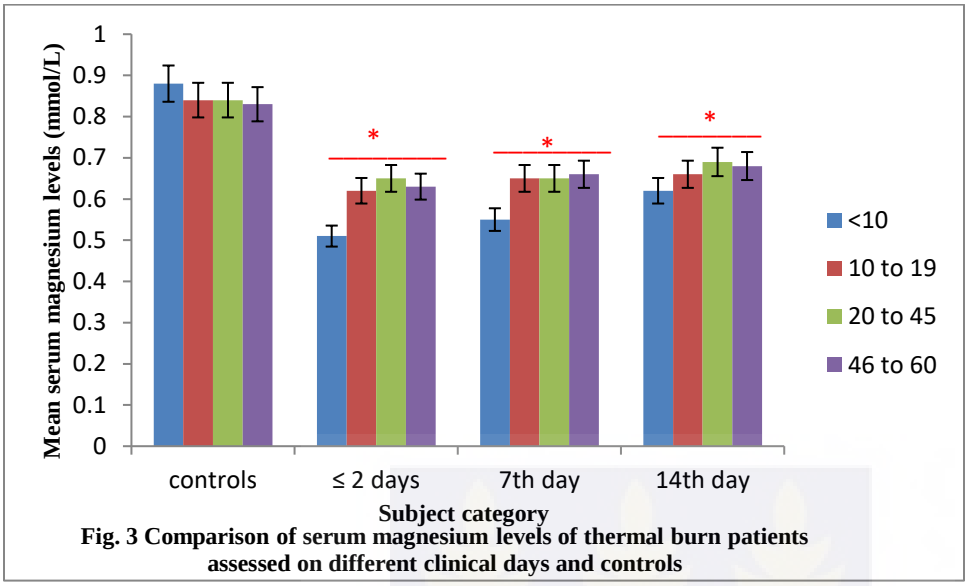

Fig. 3 Comparison of serum magnesium levels of thermal burn patients assessed on different clinical days and controls

* indicates significant difference between control and thermal burns study groups

- <10 indicates children
- 10 to 19 indicates adolescent
- 20 to 45 indicates adults
- 46 to 60 indicates middle-aged

4.5 Comparison of serum urea levels among thermal burn patients on ≤ 2, 7th and 14th days of the various age groups; children, adolescents and adults to their respective controls

From the results, serum urea levels for patients on ≤ 2, 7th and 14th days post thermal burns and controls, the results show that serum urea levels were significantly low on ≤ 2, 7th and 14th days post thermal burns in Children (p =0.010), Adolescents (p =0.04), Adults (p =0.021) and Middle aged (p =0.001) (Fig. 4). The serum urea levels rose significantly high for the children and adolescent on the ≤ 2 and the 7th post burns days (p =0.018), (p =0.006), (p =0.001) as shown below. However, in the adolescents there was a further significant decrease in serum urea level on the 14th day of post burns (p =0.002).

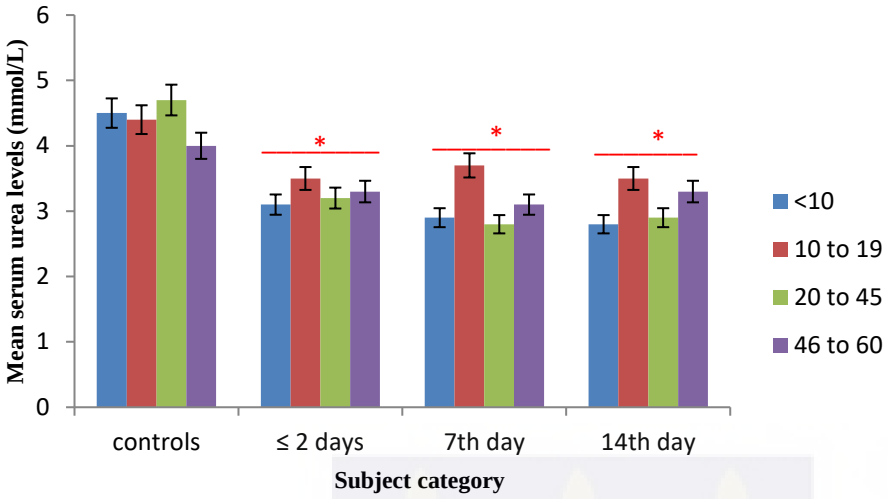

Fig. 4 Comparison of serum urea levels among thermal burn patients assessed on different clinical days and controls

* indicates significant difference between control and thermal burns study groups

- <10 indicates children
- 10 to 19 indicates adolescent
- 20 to 45 indicates adults
- 46 to 60 indicates middle-aged

4.6 Comparison of serum creatinine levels among thermal burn patients on ≤ 2, 7th and 14th days of the various age groups; children, adolescents and adults to their respective controls

The analysis revealed that the serum creatinine levels for patients on ≤ 2, 7th and 14th days post thermal burns and controls, the results show that serum creatinine levels were significantly low on ≤ 2, 7th and 14th days post thermal burns in Children ($p = 0.001$), Adolescents ($p = 0.005$), Adults ($p = 0.002$) and Middle aged ($p = 0.008$) with 14th day recording the lowest serum creatinine level in adolescent age group (Fig. 5). The serum creatinine levels rose significantly high for the children and Middle aged on the 14th post burns days ($p = 0.002$), ($p = 0.001$), respectively (Fig. 5). However, in the adolescents and adult there was a decrease in serum creatinine level on the 14th day of post burns ($p = 0.006$) (Fig. 5).

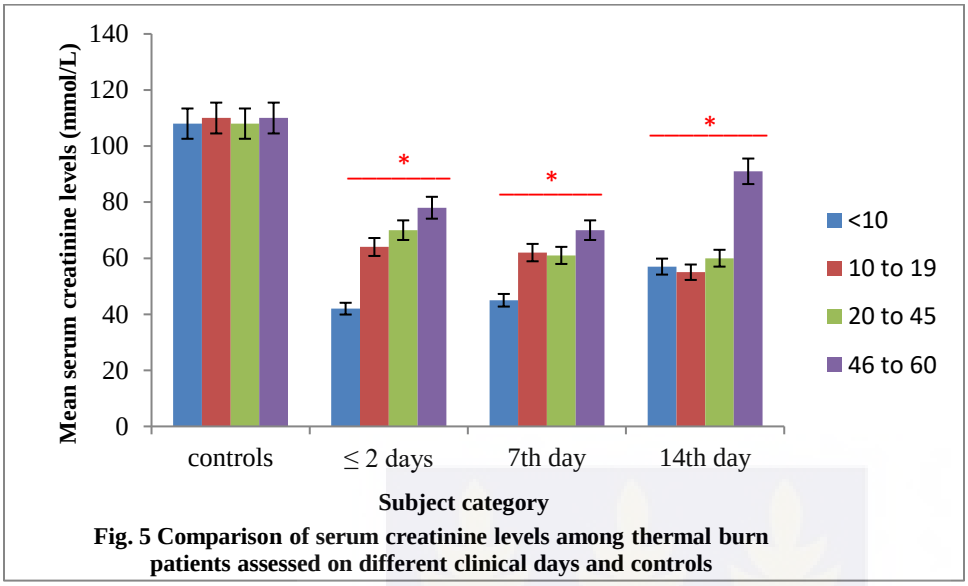

Fig. 5 Comparison of serum creatinine levels among thermal burn patients assessed on different clinical days and controls

* indicates significant difference between control and thermal burns study groups

- <10 indicates children
- 10 to 19 indicates adolescent
- 20 to 45 indicates adults
- 46 to 60 indicates middle-aged

4.7 Comparison of serum total protein levels among thermal burn patients on ≤ 2, 7th and 14th days of the various age groups; children, adolescents, adults and middle aged to their respective controls

From the results, the serum total protein levels for patients on ≤ 2, 7th and 14th days post thermal burns and controls, the results show that serum total protein levels were significantly low on ≤ 2, 7th and 14th days post thermal burns in Children ($p = 0.001$), Adolescents ($p < 0.001$), Adults ($p = 0.002$) and Middle aged ($p = 0.001$) with 14th day recording the highest serum total protein level in Children and middle aged groups respectively (Fig. 6). The serum total protein levels rose significantly high for the children and Middle aged on the 7th and the 14th post burns days ($p = 0.012$), ($p=0.007$) respectively (Fig. 6). However, in the adults there was no significant difference in serum total protein levels on the presentation ≤ 2 post burns ($p=0.001$), 7th day of post burns ($p = 0.026$) and on the 14th day ($p = 0.008$) (Fig. 6).

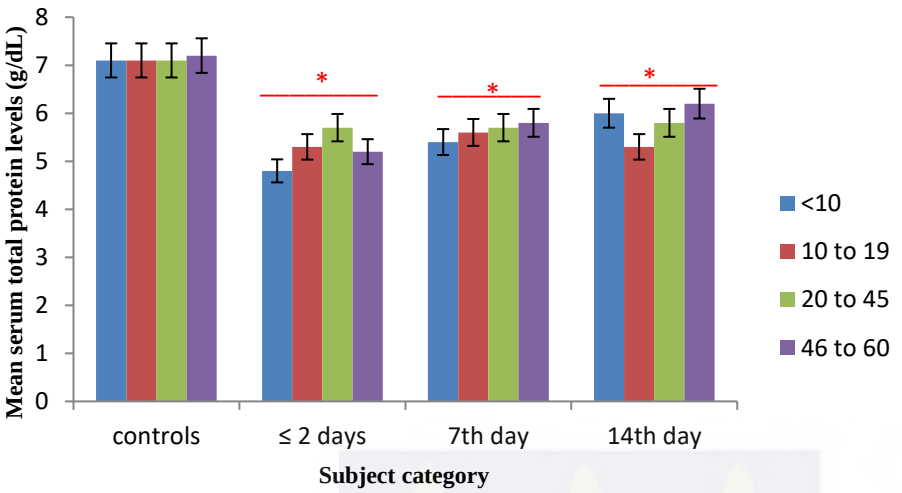

Fig. 6 Comparison of serum total protein levels among thermal burn patients assessed on different clinical days and controls

* indicates significant difference between control and thermal burns study groups

- <10 indicates children
- 10 to 19 indicates adolescent
- 20 to 45 indicates adults
- 46 to 60 indicates middle-aged

4.8 Comparison of serum albumin levels among thermal burn patients on ≤ 2, 7th and 14th days of the various age groups; children, adolescents and adults to their respective controls

The serum albumin levels for patients on ≤ 2, 7th and 14th days post thermal burns and controls, the results show that serum albumin levels were significantly low on ≤ 2, 7th and 14th days post thermal burns in Children (p =0.004), Adolescents (p =0.003), Adults (p =0.007) and Middle aged (p =0.009) with ≤ 2 recording the lowest serum sodium level in all age groups (Fig. 7) respectively. The serum albumin levels rose significantly high for all the aged on the 7th and the 14th post burns days (p =0.009), (p =0.004), (p =0.003) respectively (Fig. 7).

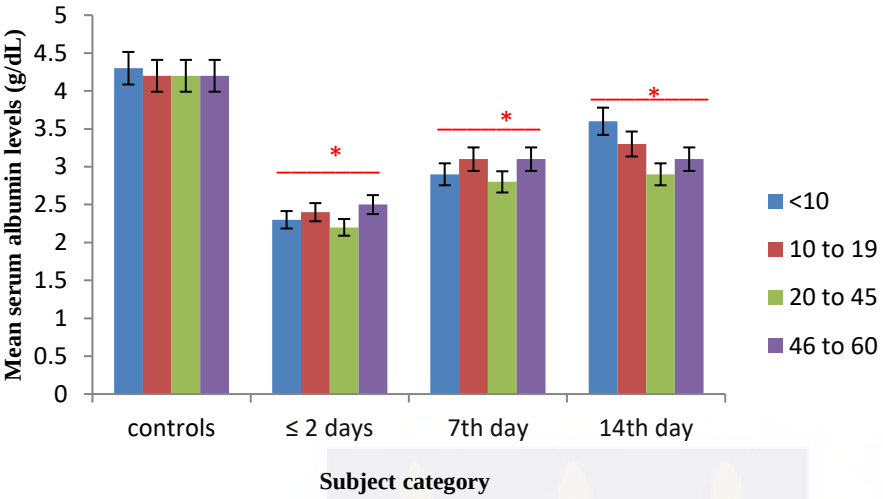

Fig. 7 Comparison of serum albumin levels among thermal burn patients assessed on different clinical days and controls

* indicates significant difference between control and thermal burns study groups

- <10 indicates children
- 10 to 19 indicates adolescent
- 20 to 45 indicates adults
- 46 to 60 indicates middle-aged

4.9 Comparison of serum globulin levels among thermal burn patients on ≤ 2, 7th and 14th days of the various age groups; children, adolescents, adults and middle aged to their respective controls

In a multiple comparison of serum globulin levels for patients on ≤ 2, 7th and 14th days post thermal burns and controls, the results show that serum globulin levels were significantly low on ≤ 2, 7th and 14th days post thermal burns in Children ($p = 0.003$), Adolescents ($p = 0.009$), Adults ($p = 0.002$) and Middle aged ($p = 0.004$) respectively (Fig. 8). The serum globulin levels rose significantly high for the children, and Middle aged on the 7th and the 14th post burns days ($p = 0.005$), ($p = 0.001$) respectively (Fig. 8). However, the serum globulin levels fell significantly low for the adolescent and adults on the 7th and the 14th post burns days ($p = 0.007$), ($p = 0.002$) respectively (Fig. 8).

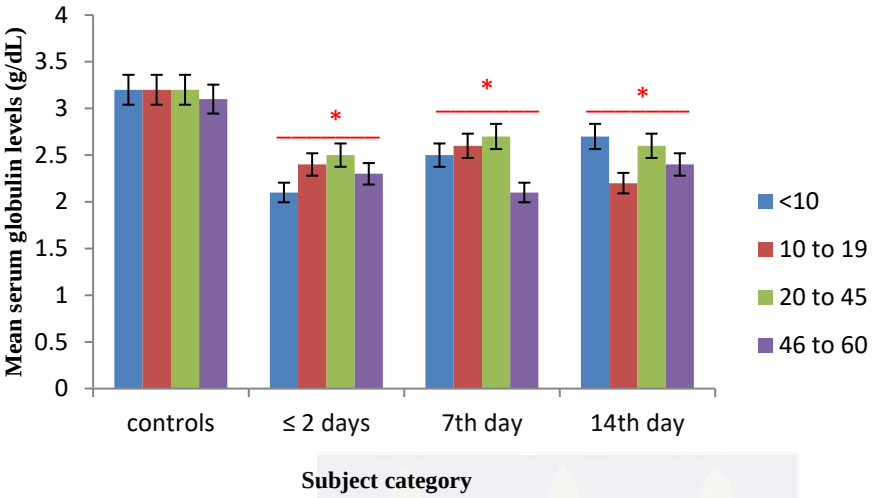

Fig. 8 Comparison of serum globulin levels among thermal burn patients assessed on different clinical days and controls

* indicates significant difference between control and thermal burns study groups

- <10 indicates children
- 10 to 19 indicates adolescent
- 20 to 45 indicates adults
- 46 to 60 indicates middle-aged

CHAPTER FIVE

DISCUSSION

5.0 Introduction

This study was aimed at estimating selected biochemical changes in thermal burns patients, since the levels of these substances are very important in informing the health care team to know how the body is responding to the different therapies that are being provided.

5.1 Characteristics of Study Participants

The study participants below 10 years constituted most this study population followed by the adults with the middle age being the least. This result is consistent with (Cronin *et al.*, 1996; Karimi, 2014). The high incidence of TBI among young children and young adult is explained by the fact that children are generally active and exposed to hazardous situations both at home, school, play grounds and work place. However, the low percentage of middle aged in the present study might be explained by the social structure in the Ghanaian setup as older members usually live within the family, thus decreasing their exposure to hazardous situations.

The percentage of the female participants was more than that of the male participants. Majority of the patients suffered superficial burns as compared to those who had deep burns. This is explained by the fact that women do most of the kitchen work especially cooking in the Ghanaian culture. Therefore, this exposes them to a higher risk of TBI.

Furthermore, the results showed that the burn injuries were mostly caused by scalds which was followed by gas explosion and the least caused was by contact with other hot objects as shown in Table 4.1. This result is consistent with (Cronin *et al.*, 1996; WHO, 2008). This is explained by high use of gas cookers, use of open coal and wood fires and use of pressure stoves for cooking in urban areas. Scalds among the children are frequent occurrence at home (WHO, 2006). This

pattern suggests certain life style, behavior of individual and age group predisposition to burn. Searching, suspicious nature and lack of knowledge of danger, play some role in burn injury of children while the young adults are burnt because they are in the active part of life to tackle all situations both at home as well as work. Middle aged persons are at the less active part of life and therefore are less exposed to these TBI dangers.

5.2 Serum sodium levels in thermal burn patients.

The results show that serum sodium levels were significantly low in the thermal burns patients in general (Fig. 1). However, these serum sodium levels rose significantly high for the children, Adults and Middle aged on the 7^{th} and the 14^{th} post burns. This result is consistent with that of with Huang *et al.,* (1995) who reported that during the first 3 days after burn, serum sodium concentrations were moderately elevated in the patients. Another report from Darling *et al.,* (1996*)* also supported the same results. Darling *et al.,* (1996) pointed out that serum Na^+ decreased post-burn and increased after resuscitation. Other study also found that the initial resuscitation period below 36 hours was characterized by hyponatraemia (Al-Muhammadi and Azeez, 2011). This could be explained that, in major burns intravascular fluid volume is lost in the burnt and the unburnt tissues; this process is due to an increase in vascular permeability, increased interstitial osmotic pressure in burn tissue and cellular edema with the most significant shifts occurring within the first hour post thermal burns. Hyponatraemia is frequent, making the restoration of sodium losses in the burn tissue essential. While the hypernatraemia is caused by several mechanisms: intracellular sodium mobilization, reabsorption of cellular edema, urinary retention of sodium due to the increase in renin, angiotensin and ADH, and the use of isotonic or hypertonic fluids in the clinical resuscitation phase (Demling and Orgill, 2000).

5.3 Serum potassium levels in thermal burn patients

The result from this study shows that serum potassium levels were significantly high on ≥ 2, 7th and 14th days post thermal burns in all patient categories as compared to controls. However, there was a decline in the potassium levels on the 14th day post burns period (Fig. 2). This result agrees with that of Al-Muhammadi and Azeez, (2011), who reported a significant increase in serum potassium of males and females before resuscitation in comparison with healthy controls. The results for this study is also supported by another study which reported that in major burns, the initial resuscitation period (between 0 and 36hrs) is characterized by hyperkalaemia (Al-Muhammadi and Azeez, 2011). The hyperkalaemia experienced at this stage has been attributed to massive tissue necrosis (Demling and Orgill, 2000). While the levels of the serum potassium levels after resuscitation in this study are significantly decreased in comparison with healthy control (Fig. 2). These results are also in agreement with Rainer *et al.*, (1999). This could be explained that, hypokalaemia is experienced after stress states and has been attributed to a combination of the effect of adrenaline and insulin. Adrenaline stimulates receptors on skeletal muscle with consequent uptake of potassium from the circulation. It may be possible that total body potassium is not reduced. The hypokalaemia experienced by burnt patients after resuscitation could be due to increased potassium losses through urine, gastric, fecal and the intracellular shift of potassium because of the administration of carbohydrates (Demling and Orgill, 2000).

5.4 Serum magnesium levels in thermal burn patients

The results revealed that the serum magnesium levels for patients on ≤ 2, 7th and 14th days post thermal burns were generally low as in all patient categories as compared to controls. This result is consistent with a study by Akhtar *et al.*, (1994) who reported that hypomagnesemia in the burn

patient is commonly described and seems to occur only on post burn day 3 (Akhtar *et al.*, 1994). Magnesium is important for all reactions requiring ATP and in all reactions involving replication, transcription, and translation of nucleic acids. Therefore, after thermal burns a large amount of magnesium is consumed by the body in an attempt to restore homeostasis hence the manifestation of the hypomagnesemia. This may result in increased neuronal irritability and tetany with severe hypomagnesemia inducing seizures, confusion, and coma. Cardiovascular abnormalities include coronary artery spasm, cardiac failure, dysrhythmias, and hypotension may also result with the hypomagnesemia (El Danaf *et al.*, 1991).

5.5 Serum urea and serum creatinine levels among thermal burn patients

The results show that serum urea and creatinine levels were significantly low on ≤ 2, 7th and 14th days post thermal burns in all patients. This is consistent with Loirat *et al.*, (1995) and Eklund and Järnberg, (1982). During the hypermetabolic phase in thermal burnt patients, beginning 48 hours after the thermal injury, an increased cardiac output is observed as a compensatory mechanism, with a concomitant increase in blood flow to the kidneys and liver. Consequently, there is an increase in the glomerular filtration rate (GFR), increasing creatinine clearance Bonate, (1990) which may explain the lower serum urea and creatinine levels in the burnt patients.

5.6 Serum total protein levels in thermal burn patients

The result of this study revealed that serum total protein was significant decrease in the all age groups for burn patients in comparison with healthy controls (Fig. 6). This study was supported by a study done by Çakir *et al.*, (2004) who reported that a marked decreased in plasma protein occur early post burn. It is reported that burns injury results in dramatic changes in plasma proteins in which the concentration of protein reduces significantly lower in serum of patient

than in controls (Banta *et al.*, 2007). The results from this study is also consistent with that of Samuelsson *et al.*, (2006) who states that there is loss of homeostatic control as a result of massive losses of fluid and protein during the first 24 hours.

The massive amount of fluid needed during resuscitation, particularly in larger burns, creates a generalized edema that is caused both by the volume of fluid itself and the decreased colloid osmotic pressure that will develop secondary to the resuscitation fluid given and to proteins lost from the circulation. This may compromise tissue perfusion in both injured and uninjured tissues of the burn-injured patients. These results occur because local inflammatory cytokines enter the circulation and result in systemic inflammatory response. As burns approach 25% of TBSA, this will lead the microvascular leak to become generalized and permit the loss of fluid and protein from the intravascular compartment to the extravascular compartment and finally they are lost through the wound (Brunicardi *et al.*, 2009).

5.7 Serum albumin levels in thermal burn patients

The results of serum albumin of thermal burnt patients of all age groups show significant decrease in comparison with healthy controls. This result is consistent with Darling *et al*., (1996) who states that serum albumin concentration decreased gradually after resuscitation. Other reports have also suggested that initial serum albumin level may be useful as an indicator for prognosis and severity of injury in burned patients. Low serum albumin level is associated with an increase in mortality rate in the major burn patients (Al-Muhammadi and Azeez, 2011). Furthermore, hypoalbuminemia may result in impaired wound healing and predisposing to sepsis (HoKim *et al.*, 2003).

The lower levels of albumin recorded may be due to stress, trauma and infection since these have always been associated with hypoalbuminemia in either animals or humans (Fearon *et al.*, 1998;

Voisin *et al.*, 1998). A reduction of plasma albumin concentration in general can be the consequence of various factors, including a change in its rate of synthesis, an increased catabolic rate, and/or a redistribution of albumin from plasma to interstitial compartment. While in burn, plasma albumin is well known to decrease in response to inflammation (Ruot *et al.*, 2000). Since the intravascular compartment which is easily accessible, represents <35% of the total exchangeable albumin pool and decrease in plasma albumin synthesis rate during the acute phase has not been observed, hypoalbuminemia could be due to an increase in either catabolism or escape of the protein from the plasma pool in the extravascular space (Ruot *et al.*, 2000).

5.8 Serum globulin levels in thermal burn patients

The results of serum globulin of thermal burnt patients of all age categories show significant decrease in comparison with control group. This result is consistent with that of Rothenbach *et al.*, (2004) and Al-Muhammadi and Azeez, (2011). Thermal burn injury induces rapid decrease in globulin values. As well as, the production of immunoglobulin G (IgG) in response to T-cell-dependent antigens is also impaired after serious injury.

CHAPTER SIX

CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

6.1 Conclusions

- Children and adult had higher incidence TBIs as compared to the adolescent and the middle-aged age groups.
- The serum levels of sodium and serum magnesium were found to be generally low whereas serum potassium levels were high in thermal burnt patients of all ages as compared to controls.
- Serum albumin, globulin and total proteins were decreased in thermal burnt patients of all ages as compared to controls.
- Serum urea and creatinine levels were also found to be low thermal burnt patients in all age categories.
- Carefully monitoring of these biochemical parameters can help improve the health of TBI patients, reduce mortality rate and improve survival.

6.2 Limitation

The main limitations of this study were the high cost of biochemical analyses of thermal burns patients which limited the number of biochemical parameters that were analyzed.

6.3 Recommendation

Studies need to be conducted to determine the levels of these biochemical parameters as predictors of prognosis in burn injuries.

Further clinical trials of larger sample size and longer duration on admission need to be conducted.

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APPENDIX I

CLINICAL SURVEY SHEET

1. **ID Number/Code**…… Date of Recruitment…….
2. Gender/sex: female [ ] male [ ]
3. Age……
4. Address/Telephone number…….
5. Occupation……
6. Blood pressure……mmHg
7. Pulse rate……..bpm
8. Details of burn injury

   Date/ Time of burn……

   Date/ Time of presentation……
9. Brief history of burn

   Etiology…….

   Place of burn…….

   Circumstance of injury……..
10. Depth of burn:

    Superficial burn [ ]

    Deep burn [ ]
11. Affected parts of body:

    Total % burn……. % TBSA
12. Outcome of burn period …….

APPENDIX II

7.0 Ethical Issues

7.1 Approval

The proposal of this study was submitted to the Research Protocol and Ethical Review Committee of the University of Ghana School of Biomedical and Allied Health Sciences for review and approval.

7.2 Confidentiality

Subjects were made to complete informed consent forms and laboratory sheets and were signed by the supervisors of this study. The data gathered from the subjects will be used only for the purpose of the study and the subjects will be assured of complete confidentiality of any information obtained from them.

7.3 Voluntary Written Informed Consent

As part of the requirements for ethical considerations, a written informed consent was obtained from the Stroke Unit of the Korle Bu Teaching Hospital and the Biochemistry Department of the University of Ghana School of Biomedical and Allied Health Sciences in order to use their laboratories for the sample collections and analyses respectfully. A detailed written informed consent stating the title and the purpose of the study was given to the subjects for their consents. In addition, detailed explanations on the need to participate in this study will be emphasized. The consent form was attached to this proposal for approval by the Research Protocol and Ethical Review Committee of the University of Ghana Medical School and School of Biomedical and Allied Health Sciences.

7.4 Potential Risks

The most probable potential risks which was associated with this study was the pains that subjects experienced as a result of blood sample collections which was made at baseline.

7.5 Safety Precautions

The standard protocol for conducting a study of this nature was duly followed. Participants underwent a thorough medical screening and health history questionnaire. Participants were taken through a familiarization section to get themselves acquainted to the procedure. In addition, heart rates and blood pressures were monitored during the procedure.

7.6 Benefits

The results of this study will be useful to the participants, entire burn population, college of health sciences, and clinicians as well as the general public. Subjects having successfully gone through the study will appreciate the impact of biochemical variations in thermal burn patients and as well as its potential effect in complications Burn survivors in Ghana. Clinicians especially, those in medicine and exercise prescription and supervisions such as Physicians, Vascular Physiologists and Dieticians will be guided on how to design planned structured treatment programme for their burn patients or clients. In terms of research, this will stimulate more work in this area in Ghana.

7.7 Informed Consent

Subject's Name: …… **Date:** ……..…

Introduction

The title for this study is "changes in selected biochemical parameters after thermal burns at the korle bu teaching hospital". The aim of this study is to determine changes in **selected** biochemical parameters in thermally burnt patients who report at the (burn unit) at Korle-Bu

Teaching Hospital. Your role in this study will be: as a thermal burn patients being recruited into either superficial or deep burn injury. Burn etiology, severity and outcome will be taken and recorded. About 10mls of blood samples will be drawn and used for analyses.

Risk and Discomfort

Participating in this study will not be detrimental to your health. Potential risks and safety precautions have been taken care of. However, you reserve the right to withdraw from the study at any point in the study. Nevertheless, you will experience some discomfort from the parameters that will be measured and discomfort from venipuncture.

Confidentiality

Your confidentiality concerning any information given towards this study will be purposely used for this study alone and these data will be kept as confidential as possible. Your identity will be kept anonymous when the results are presented or published. All persons involved in the study will be referred to as "Participants".

Problems or Questions

If you have any problem or question about this study, you can contact the investigator: Kwaku Boakye Achampong (0249797258/ 0205710801) in the Department of Physiology, University of Ghana, School of Biomedical and Allied Health Sciences.

Consent

I have read or have had someone read to me, the entire explanation of this study and have been given the opportunity to discuss any questions. I understand the nature, risk and benefits of this study and that I may withdraw at any time from the study. Likewise, I have received a copy of this informed consent document. I hereby consent to take part in this study.

Subject's Signature……..… **Date Signed**……

Investigator's Signature…… **Date Signed**……..