PEDIATRIC ELBOW FRACTURE PATTERN AND ASSOCIATION WITH BODY MASS INDEX

BY

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DECLARATION

I hereby declare that this study is my original work and has not been presented as a dissertation at any other university.

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LIST OF ABBREVIATIONS

KNH……………………………....   Kenyatta National Hospital

RTA……………………………….   Road traffic Accidents

CDC……………………………….   Centers for Disease control and Prevention.

UoN………………………………..   University of Nairobi.

ERC………………………………..   Ethics and Research Committee.

BMI………………………………...   Body Mass Index.

BMD………………………………..Bone Mineral Density.

SCF………………………………..   Supracondylar fractures of humerus.

AIN………………………………...Anterior interosseous Nerve.

1. ABSTRACT

Background:

Pediatric fractures around elbow region constitute a large burden of injuries treated in trauma hospitals. Elbow fractures in children make up about 5-10% of all fractures in pediatric patients with distal humeral supracondylar fractures accounting for approximately 60%. The epidemiological profile of elbow fractures in children vary in different regions due to the fact that geographic areas, demographics, climate, social life/structures differ from one part of the world to another. Pediatric obesity has reached epidemic proportions globally. The risk of musculoskeletal injuries is reportedly higher in obese and overweight children as compared with their normal-weight peers. Furthermore, the risk of sustaining forearm fractures especially from low energy mechanisms and chances of sustaining an extremity fracture requiring surgery is higher in obese and overweight children than in the normal-weight counterparts. However, it is unclear what role body mass index plays in fractures about the elbow.

Objectives: This study aimed to determine the pattern of pediatric elbow fractures as seen at KNH and to determine the association between pediatric elbow fractures and BMI.

Study Design:

This was a cross sectional descriptive study.

Study site

This study was conducted at Kenyatta National hospital casualty, Children's orthopedic wards and orthopedic fracture clinics.

Methodology;

The study population consisted of all children aged fourteen years and below who sustained acute trauma and had a fracture around their elbow. The study had 116 participants. All patients seen over a period of three months (June – Aug 2019) were registered, listed and assigned consecutive numbers. Population census was used.

Patients demographics and injury characteristics that included age, sex, height, weight, body mass index, time of injury, upper extremity affected, mechanism of injury, fracture type, place of injury, associated injuries including neurovascular status were recorded in a prepared questionnaire. The primary researcher or his two assistants, qualified orthopedic trauma technologists, collected the data. Height and weight measurements were used to calculate the BMI. The BMI was used to get the patient's body mass index percentile for sex and age according to the Centers for Disease Control and Prevention growth chart. A physical exam of the ipsilateral extremity was carried out to determine the elbow injury and associated injuries. Standard anteroposterior and lateral view plain radiographs was used to identify the elbow fracture, associated ipsilateral upper extremity fractures and elbow dislocation.

Results

116 participants were recruited. Males were 80(69%).Female were 36(31%).The mean age was 7 years with an age range of 2-14 years. The most common fracture was supracondylar (77%) followed by lateral condyle (7%) and medial epicondyle (6%). Most of the injuries occurred at school 65(56%), followed by home 49(42%).The left elbow (51%) was injured more than the right. The most common mechanism of injury was fall (95%), followed by contact sports (3%). Association between pediatric elbow fractures and BMI was not analyzed due to the low numbers of children in the overweight and obese categories who sustained elbow fractures. Sub analysis of supracondylar humeral fractures and BMI showed more obese children sustained gartland type 3 fractures than the other types (p=0.031) and there was no correlation with BMI. Univariate logistic regression showed a significant correlation between age (p 0.003), sex (p 0.002) and weight (p 0.002) for supracondylar fracture severity. Sex and BMI were not positive covariates on univariate regression. On multivariate logistic regression age, height and weight after controlling for BMI and sex showed no correlation with fracture severity.

Conclusion

Majority of elbow fractures are supracondylar humeral fractures followed by lateral condyle fractures and medial epicondyle fractures respectively. Majority of the elbow injuries occurred in the school with the most common mechanism of injury being fall from ground level. The peak age of injury is between 3-8 years. Body mass index has no association with pediatric elbow fracture severity.

2. INTRODUCTION:

Elbow fractures are common traumatic injuries in the pediatric population and contributes to approximately 5-10% of the all fractures in children (1,2). Despite the fact that an extremity fracture is rarely life threatening, they may cause increased morbidity, inability to work and increased psychological distress (3). Children tend to fall with their arms outstretched and thus fractures of the upper extremity constitute 65% to 75% of all fractures (4,5).

In a study of elbow fractures in children less than sixteen years done in Sweden the average annual incidence was found to be 12 per 10,000 (10.0 - 14.7)(5). A similar study in Denmark found the incidence of pediatric elbow fracture to be 308/100,000(6). In Africa, a study from Senegal found an incidence of 58.12 per 10,000 patients (7).

A pediatric study done at KNH in 2017 found out that the upper limb was involved in 53% of long bones fractures in children with supracondylar humerus fractures being the most common (4). No other types of elbow fractures were noted.

As compared to adults, elbow fractures in children have a higher incidence and greater variability in the fracture pattern. This is explained by the changing intrinsic bone properties as the child grows. Elbow fracture types in children include supracondylar humerus fractures, lateral condyle fractures, neck of radius fractures, medial epicondyle fractures, olecranon fractures, radial head fractures, capitellum fractures and intercondylar fractures (2,5,6,8).In children elbow fractures incidence is on the rise. This is attributed to increased levels of participation of children in recreational and organized competitive sports (5,6).

The peak incident age of elbow fractures in children reported in literature is 4-8 years of age. The left non-dominant hand is involved in approximately 60% of cases. Boys are more affected than girls in all age groups (7,9,10). Majority of the injuries occur at home or in the vicinity with a smaller proportion occurring at school (4,10,11).

In terms of mechanism of injury, it varies, with a direct blow to the elbow or a fall on an outstretched hand with valgus, varus, rotational or a combination thereof being most common. The type of fracture that occurs is determined by the degree of chondro-osseous development and the vectors of forces applied at the elbow. Another common mechanism of elbow injuries are road traffic accidents. With increased urbanization, there is increased registration of motor vehicles and motorcycles on our roads with subsequent increase in road traffic accidents. Children account for about 20-40% of RTA victims (12). In most literature, road traffic accidents contribute about 2-10% of elbow fractures (4–6,8).

Acute traumatic elbow injury in a child may result in a bony, cartilaginous or soft tissue injury. Associated injuries in elbow fractures include elbow dislocations, soft tissue injuries, concomitant upper extremity fractures and neurovascular injuries. Studies have shown incidence of associated injuries are related to severity of the elbow fractures, increased complications and poor outcomes in patients with these injuries (13–15).

Being overweight has been shown to be associated with suboptimal bone strength and development (16). Overweight children have an increased risk of fracture. Various studies have documented the association between obesity and an increased risk of musculoskeletal injuries (17–19). Overweight and obese individuals have been shown in some studies to be predisposed to certain types of upper extremity fractures especially the distal forearm (20–22). Severity of the injury is also higher in overweight/obese individuals than in normal weight peers (23,24). The reason for high rates of fractures has been attributed to the increased momentum of a greater body mass during injury and lack of physical activity leading to decreased muscle mass, strength and coordination resulting in impaired proprioception and balance. This increases risk of falling and fracture. However other studies have shown no difference in fracture patterns or severity between obese and overweight versus their normal-weight peers (25,26).

Elbow fractures in children have different patterns in different regions since social life and social structures are different in different geographical areas (5,6,8). Comprehending the circumstances of how traumatic injuries happen in children is important for formulating effective injury prevention mechanisms and adapting treatment to optimize outcomes. Locally there is a paucity of data on the distribution, cause, place of injury and associated injuries of childhood fractures of elbow.

3. LITERATURE REVIEW:

3.1 Demographic data:

3.1.1 Age and gender of patient

Age specific fracture patterns and location within the elbow joint are influenced by age-specific dependent activities and changing intrinsic bone properties. The peak age of incidence of childhood fractures is age 14 for boys and 11 for girls (27). Peak incidence of elbow fractures is 4-8 years age group (5–7,10). Gender difference can be seen across the incidence of fractures, location of injuries and etiology of injuries across all age groups. Boys consistently have a higher fracture rate than girls (22,23). However, a study from Denmark found female predominance of pediatric elbow fractures(6).

Transphyseal elbow fractures occur in children 2 years of age or less (24,25). Young children in the 5 to 10 year age group sustain supracondylar humerus and lateral condyle fractures after a fall (1,7,10,26,27). Radial head, capitellar and T or Y distal humerus fractures occur commonly in the adolescent age group(28).

Body Mass Index.

A child is classified as underweight if his or her body mass index is below the 5^{th} percentile for age and sex, 5^{th} to 85^{th} percentile is normal, 85^{th} to 95^{th} percentile is overweight and greater than 95^{th} percentile is obese. Literature on association between childhood fractures and obesity is controversial. Being overweight has been associated with increased incidence of skeletal fractures in children (20,22,23,29,30). A higher fracture risk in obese children may be the result of greater forces generated during a fall, a lifestyle contraindicative to strong bones and/or excess fat tissue that impairs bone strength development (16). However, other studies have shown no difference in fracture patterns or severity between obese children and non-obese children (25,26,31,32). Few studies have defined the relationship between BMI and elbow fractures in children.

3.2 Place of injury

A large proportion of childhood fractures occur in or around the home in approximately 45-80% (4,8,10,32–34). In a local study conducted at Kenyatta National Hospital on pattern of long bone fractures in children, 56% of the injuries occurred at home (4). A similar local study of children who fall from a height as seen at KNH noted that approximately 76 percent occurred at home(34). Supracondylar fractures were the commonest fracture in both studies. Injuries in infants and toddlers involved falls from cots, beds and tripping over furniture. Older children sustain elbow fractures from playground fixtures (trampolines and home jungle gyms) around the home, falls from fences and trees.

Fractures at school are proportionately fewer than injuries occurring at home and are pegged at between 2-16% (8,11,35). Most injuries in school occur as a result of injury from playground equipment and participation in athletic and contact sports.

Other location where pediatric elbow injuries occur include public playgrounds. Loder et al when evaluating demographics of playground equipment injuries in children found that falling from the monkey bars was the most common cause of fractures with a peak age group of 5-12 years and supracondylar humerus fractures were the most common (36). A local study in KNH found out that injuries occurring at public playground constituted 13%(4).

3.3 Mechanism of injury

A fall is the most common mechanism of injury leading to elbow fractures reported in most literature. Falls can vary in complexity from a simple fall while running to a fall from height. A child tends to fall on an outstretched hand and thus the high proportions of elbow fractures. In a study done at KNH, it was discovered that fractures comprised 43.3% of injuries sustained by children who fell from a height with supracondylar humerus fractures comprising 19.7% (34). In 2017, a study on pediatric long bone fractures found that 56% of fractures were caused by falls with elbow fractures comprising approximately 16% (4). In other studies, fall as a cause of elbow fracture range from 20-54% (5,6,8,33,35). Falls from slight trauma (height less than 0.5m) are the majority at 22-54% (4,6), while falls from height > 3m (severe trauma) comprised 2.8-10% (5,6).

Sports as a cause of elbow fracture in children forms a significant proportion. The incidence of pediatric elbow fractures is increasing following increased level of participation of children in recreational and competitive sports (5,28). Sports related to elbow fractures include contact sports such as soccer, rugby, basketball, volleyball, baseball. Non-contact sports related to elbow fractures include javelin, tennis and athletics. Landin et al and Houshian et al found 21% and 49.6% respectively of all elbow fractures in children was as a result of sports and equipment-related leisure activity. Locally 13% of fractures to the long bones were as a result of sporting activity related to contact sports mainly football (4).

Road traffic accidents contributes about 10% of elbow fractures in children various studies (5–8,10).These mostly involved children being struck by motor vehicles while playing or walking to school. With increase in motorcycle registration in the country, the number of various fractures in young adults has increased significantly (37,38). This trend would also be expected in childhood fractures although data is lacking.

Recreational activities such as skateboarding, roller-skating and bicycling have taken on a new look in the era of extreme sports. Such activities now involve high speed and stunts. This coupled with non-compliance with safety equipment necessary for such activities such as helmets or elbow and knee pads predispose the individual to increased risk of fractures including elbow fractures. Two studies found recreational accident to be the major cause of elbow fractures (59.5%)(6,7).

Assaults also contribute to causes of elbow fractures in children. Tandon et al attributed elbow fractures due to assault following fights among children, a child being hit with a stick or stone causing elbow injuries. Biruk et al in his study found two pediatric elbow fractures related to child abuse(10).

3.4 Anatomic site of the fracture within the elbow

Different studies have found different variations of the frequency of the various elbow fracture types in different geographic areas. Supracondylar (50%-70%), lateral condyle (17%-34%) and medial epicondyle (10%) are the three most common elbow fractures reported in pediatric orthopedic literature. Proximal radius fractures make up about 5%-10%(39).

Table A. Pediatric elbow fractures according to anatomical lesion

	SUPRACONDYLAR n(%)	LATERAL CONDYLE n(%)	MEDIAL EPICONDYLE n(%)	RADIAL NECK n(%)	OLECRANON n(%)	RADIAL HEAD n(%)	T or Y n(%)	COMBINATION MISCELLENOUS n(%)	INTERCORDYLE n(%)	LATERAL EPICONDYLE n(%)	MONTEGGIA FRACTURES n(%)	CORONOID n(%)	TOTAL n(%)
Landin LA & LG D(5)	320 (55%)	67 (12%)	48 (8%)	86 (14%)	42 (7%)	9 (1.6%)	4 (0.7%)	10 (1.7%)	3 (0.5%)	-	-	-	589 (100%)
Akbar B (Iran)(8)	174 (58%)	28 (9.3%)	13 (4.5%)	22 (7.3%)	16 (5.3%)	32 (10.7%)		6 (2.0%)	9 (3.0%)	-	-	-	300 (100%)
Harold B(40)	465 (65.4%)	180 (25.3%)	-	34 (4.7%)	12 (1.6%)	-	6 (0.8%)	-	-	-	16 (2.2%)	-	713 (100%)
Donald J Maylanh(41)	177 (60%)	34 (12%)	27 (9%)	22 (7%)	-	-	6 (2%)	8 (2%)	-	-	7 (2%)		300 (100%)
Bhardwad A(33)	67 (63.9%)	16 (15.2%)	8 (7.6%)	-	4 (3.8%)	10 (9.5%)	-	-	-	-	-	-	105 (100%)
Emery KH Z SH(39)	258 (56%)	69 (15%)	27 (6%)	80 (17%)	56 (12%)	-	-	8 (2%)	-	-	-	12 (3%)	510 (100%)
Biruk LW(10)	154 (69.1%)	31 (13.9%)	11 (5.0%)	-	5 (2.3%)	3 (1.3%)	-	6 (2.7%)	-	6 (2.7%)	-	-	223 (100%)
Ndour O(7)	378 (81%)	7 (1.5%)	56 (12%)	-	6 (1.29%)	2 (0.4%)	-	-	-	16 (3.4%)			465 (100%)

Summary from the various studies seem to indicate supracondylar humerus fractures are the most common form of elbow injuries, followed by lateral condylar fractures and medial epicondyle fractures. The peak age of supracondylar fractures is the 4-10 years age group.

In Africa, a study from Senegal found out that the 3 most common elbow fracture in children were Supracondylar (81%), medial epicondyle (12%) and lateral epicondyle (3.4%) respectively (7). A similar study from Ethiopia found a different pattern with the 3 most common fractures around the elbow being supracondylar (69.1%), lateral condyle (14%) and medial epicondyle (5%) (10). This shows the different variations of elbow fractures even within the same continent due to different social and cultural setup. The clinical management of the various elbow fractures is different, with different complications and outcomes.

3.5 Associated injuries

Other injuries associated with elbow fractures include soft tissue injuries, elbow dislocations, other fractures in upper extremity excluding the elbow, such as distal radius or clavicle, nerve injuries, arterial injury and open fractures.

Soft tissue injuries are common in elbow fractures. They include ecchymosis, skin abrasions, skin tenting and skin puckering. Christine A. Ho et al in her study showed that soft tissue severity as determined by the above skin lesions has clinically significant association with neurovascular compromise (13). One study found the prevalence of skin lesions in elbow fractures to be 2.3% (7). Majority of pediatric elbow fractures are closed injuries. The incidence of open fractures in childhood fractures range from 1.5% to 2.6% (42).

Elbow dislocations are rare in the first decade of life and are common in older children involved in sporting activities (43). Traumatic elbow dislocation with associated fractures in the pediatric population represent approximately 10-12% of all elbow fractures in children (15). Incidence of elbow dislocation without fracture is low.

Fractures associated with elbow dislocation include lateral humeral condyle, medial epicondyle fracture, olecranon fractures and radial neck fractures. A Danish study found the incidence of elbow dislocation to be approximately 2.4% (6). Dislocations will be determined via the anteroposterior and lateral views of the elbow radiographs.

Other ipsilateral upper limb fractures can occur with association with elbow fractures. These associated fractures are usually associated with higher energy (axial forces) transmitted through the upper extremity bones. They may include distal radius or ulna fractures, scaphoid fractures, proximal humerus or even clavicle fractures. Concomitant supracondylar and forearm fractures have been reported to have a higher incidence of compartment syndrome and nerve injuries in some studies (44–46). One found the incidence of ipsilateral limb fractures to be 3.8% (7). Ipsilateral limb fractures will be determined through a thorough physical exam and the appropriate radiographs.

3.6 Vascular injuries in elbow fractures

Brachial artery injury can occur in elbow fractures and dislocations. Mechanisms of vascular injury are disruption of vascular wall, compression and vascular spasm. The rate of vascular injuries in elbow fracture reported in literature vary from 3.2-15% (47–49). A local study done in Kenyatta found the rate of vascular injury following supracondylar fracture to be at 2.7% and all had Gartland type 3 (50).

Close observation of vascular status by capillary refilling, radial pulse palpation, pulse oximetry monitoring and Doppler ultrasound are recommended. The dreaded vascular complication is brachial artery occlusion which can lead to compartment syndrome and possible limb loss or Volkmann's ischemic contracture. Prevention largely depends on having a high index of suspicion in a child with suggestive history, timely diagnosis and aggressive treatment (51). Early diagnosis together with prompt management of the fracture and vascular injuries is crucial to prevent these disabling complications.

Vascular exam of the limb will be assessed through clinical exam. Radial and ulna arteries will be palpated for presence or absence in comparison to the contralateral uninjured limb. Diminished pulses as compared to the contralateral pulse will be considered as vascular injury.

3.7 Nerve injuries in elbow fractures.

Acute nerve injuries are frequent complications of elbow fractures. Fractures associated with acute neurological injuries include supracondylar fractures and medial epicondyle although elbow dislocation associated with other pediatric elbow fractures can result in nerve injuries. In supracondylar fractures, neural impairment can occur in 17% (8,52). Anterior interosseous nerve, which is a branch of the median nerve is the most commonly injured nerve in supracondylar humeral fracture. A meta-analysis of 3,457 extension-type SCH fractures found an overall neuropraxia rate of 13%, with the AIN (5%) being the most common, followed by the radial nerve 4% (53). A study from Denmark found the rate of nerve injury to be 7.1%(6). with frequency of injury being median nerve (53%), radial nerve (40%) and ulna nerve (7%) respectively. At KNH, a study found the rate of nerve injury in SCF to be 4.7%(50).

Kamath AF in a systematic review of elbow medial epicondyle fractures found the rate of ulna nerve injury to be 9.6% (54).

Nerve injury is going to be determined through physical examination of the hand. Wrist and finger extension will determine motor function to radial nerve. Sensation to the radial nerve will be tested at the first web space, dorsal aspect of the hand. Motor function to the median nerve will be tested though apposition of the thumb and index finger tips. Sensation to the median nerve will be tested on the tip of the index finger. Ulna nerve motor will be tested by abducting the fingers. Sensation will be tested at the tip of the fifth digit.

3.8 Classification of Elbow Fractures.

Different types of elbow fractures have various classification systems used to identify them. Classification of these injuries is essential because it serves as a basis for guidance on the type of treatment the individual will receive.

Supracondylar humerus fracture: Approximately two thirds of all elbow fractures are supracondylar humerus fractures making them the most common. In extension type supracondylar fractures, the elbow is displaced posteriorly. It occurs in more than 95 % of cases. Flexion type occurs in about 5% of cases. The elbow is displaced anteriorly. Considering the frequency of this fracture, its low energy mechanism of injury and its ease of classification, it is ideal for testing association between BMI and supracondylar fractures occurrence.

Gartland Classification

Supracondylar fracture classification is based on degree of displacement for the extension types(55). In Gartland type 1 the fracture is minimally displaced or even occult fracture. Subtle buckling of the cortex or displaced fat pads may be the only clue. In Gartland type 2 fractures there is posterior angulation at the fracture site. The posterior cortex remains intact. Gartland type 3 fracture is a completely displaced fracture with complete cortical disruption. Flexion type supracondylar fractures will also be determined radiographically.

In summary, most studies of pediatric elbow fractures in children are retrospective, focus on specific elbow fracture types, treatment modalities or radiological aspects of pediatric elbow fractures/imaging. This will be a prospective cross sectional community based cohort study evaluating the epidemiological profile of elbow injuries in children which constitute a large burden in our setting.

Local studies have not evaluated or described elbow fracture patterns in children.

Other studies have not linked the variables in this study to pediatric elbow fractures. This include correlation of elbow fractures to age, sex, height and weight.

STUDY QUESTION

What are the patterns, mechanism of injury, place of injury and associated injuries of acute elbow fractures in children seen at Kenyatta National Hospital?

4 STUDY JUSTIFICATION

Elbow fractures are among the common injuries seen in Kenyatta National Hospital. Upper limb fractures in children constitute more than 55% of all pediatric fracture burden.

The knowledge of the epidemiology of elbow fractures is fundamental to choose the adequate prevention and control strategies for the target population. The epidemiological profile of elbow fractures in children has not been studied in Kenya.

In KNH, data on pediatric elbow fracture patterns, mechanisms of injury, place of injury associated injuries including neurovascular complications is lacking making it difficult to design preventive programs.

4.1 Objectives:

4.1.1 Primary Objective

1) To determine the pattern of pediatric elbow fractures seen at KNH.

4.1.2 Secondary Objectives

i. To determine the pattern of elbow fractures in children presenting at KNH. This is in terms of place of injury, mechanism of injury, type of elbow fracture, and associated injuries.

ii. To determine the association between BMI and elbow fractures in children.

5 MATERIALS AND METHODS:

5.1 Study Design:

Cross sectional descriptive study.

5.2 Setting

The setting of the study was at the accident and emergency department, fracture clinics and pediatric orthopedic wards at Kenyatta National Hospital.

KNH in Nairobi (Kenya) is the largest referral hospital in East and Central Africa.

5.3 Study population*:*

Inclusion criteria

All children and adolescents from birth to fourteen years of age who came to Kenyatta National Hospital with an acute elbow fracture between June 2019 to August 2019 were included. Acute fracture in this cases were less than 72 hours since injury. This is because skin lesions disappear after 72 hours.

Exclusion criteria will include:

1. Pathological fractures.
2. Elbow fractures more than 72 hours post injury.
3. Guardians or parents who declined to give consent or have radiographs taken.

5.4 Sample size:

It is estimated that elbow fractures contribute about 5% of pediatric fractures.

Utilizing the Cochran formula:

$$n_o = \frac{Z^2pq}{}$$

e^2

n_o = sample size to be determined

Z = Standard deviations at 95th percentile (1.96).

P = Expected proportion of elbow-injured patients among patients seen at A&E department (0.08).

q = 1 – P

e = Desired level of precision (0.05).

$$n_o = \frac{1.96^2 \times 0.05\ (1-0.08)}{0.05^2} = 116 \text{ participants.}$$

5.5 Study Procedures:

Sampling:

Population census was utilized. All children 14 years and below presenting at casualty, orthopedic children's ward and fracture clinics at KNH with acute traumatic elbow fracture were eligible for recruitment into the study. Acute, in this setting, was less than 72 hours post injury. Fourteen years was chosen as the upper limit since most other studies on elbow fractures took fourteen as the upper limit, so for comparison reason. World Health Organization refers to pediatrics age group as from birth up to sixteen years, fourteen years falls in that age bracket.

Participation enrolment:

Recruitment was done at the Accident and Emergency department, orthopedic wards and fracture clinics during the duration of the study.

Patients were recruited into the study by the principal researcher or his two research assistants through convenient sampling method. The two assistants were qualified orthopedic trauma technicians with experience in orthopedic practice. They were trained on collecting data using ten patients from a pilot study.

The principal researcher and/or his research assistants reviewed the patients file for eligibility into the study. Those that meet inclusion criteria were recruited into the study.

Patient demographic characteristics and injury details were recorded in the data sheets. The injured upper extremity was clinically examined for the elbow injury and associated injuries.

The post injury true anteroposterior and lateral radiographs of the involved limb was taken and assessed by the principal researcher for the pattern of the injuries and classified according to the fracture type. Patients were then managed as per the hospital protocol.

Body Mass Index: BMI was calculated by dividing weight in kilograms (kg) by height in square meters (m^2).BMI percentile specific for age and sex was determined by the CDC growth charts as established by the US Centers for Disease Control and Prevention (CDC)(56). Low weight was defined by BMI values that were below the 5th percentile (< P5); normal weight when BMI values were at or above the 5th and below the 85th percentiles (P5-P85); overweight when they were at or above the 85th and below the 95th percentile (P85-P95); and obese when they were at or above the 95th percentile ($\geq$ P95).

Supracondylar fracture type was classified according to the Gartland classification for extension-type supracondylar humeral fractures. No flexion type supracondylar fractures were documented. Other elbow fractures were classified as per their anatomical locations on the radiograph e.g. medial epicondyle.

Stature: Height was measured using stadiometer attached to the weighing scale. The child stood with feet flat, together, legs straight, arms to the side and shoulders should be level(57). The participant was asked to look straight ahead and the line of sight was parallel to the floor. Patients unable to stand were measured in bed with limbs and trunk in full extension. Measurement from top of the head to the sole of foot was recorded. Measurement was carefully read to the nearest 0.1cm.

Weight: Weight was taken using a spring weighing scale (Seco). Each child was measured in light clothing and without shoes or socks. It was recorded to the nearest 0.1kg.

5.6 Quality control

Quality assurance protocol involved checking and recalibrating of equipment and monitoring the performance of the assistants. Calibration occurred at the beginning and end of each examining day. The scale was checked using the standard weights and calibration was corrected if the error is greater than 0.1kg. The results of checking and recalibrations was recorded in a logbook.

The height ruler was also checked daily with standardized rods and corrected if the error is greater than 2mm.The results of the checking and recalibrations was recorded in the logbook.

The assistants received training before the start of the study which included lecture and practice measurements. Practice measure was done under supervision. I worked closely with the assistants and regularly supervised them to ensure they complied with the measuring procedures.

After the data collection was complete, retrospective quality assessment was made on the pooled data of all measurers and it included:

(i) Distribution of terminal digits for weight and height measurements

(ii) Distribution of terminal digit for full kilograms for weight measurement.

(iii) Mean and standard deviation of weight and height measurements.

5.7 Analysis and management of data:

Data was coded, entered and managed in a Microsoft Access database and at the end of data collection was transferred to STATA for analysis. Demographic and injury characteristics and the patterns of elbow fractures was analyzed descriptively. The data was summarized in terms of means, modes and median. Presentation was in form of tables, graphs and charts. A Pearson causal correlation coefficient was calculated to assess the relationship between the pediatric elbow fracture and BMIAssociation between supracondylar humeral fracture severity and BMI was also assessed using logistic regression analyses. A univariate regression analysis of the association between age, sex, height, weight and supracondylar fracture was done to gauge their significance. Then the significant variables were used in a multivariable regression analysis. Age, sex, height and weight are all components of BMI, therefore the simplified regression contained an analysis of the association between supracondylar severity and BMI.

6 ETHICAL CONCERNS

Ethical approval was sought from the department of orthopedic surgery, UoN and ethics review committee of KNH. We obtained authorization from KNH administration prior to data collection in relation to this study.

Consent from the parents or guardians on behalf of the participants was also sought prior to enrolling them into the study.

Assent was also obtained from those patients who were six years of age and above.

7 RESULTS

Table 1.0: patient and injury demographic

Table 1

Patient Demographics

Demographics	Frequency	Percent
Sex		
Male	80	69.0
Female	36	31.0
Age, Y		
0 – 2	6	5.2
3 – 5	30	25.9
6 – 8	36	31.0
9 – 11	27	23.3
>11	17	14.7
Age (Mean &Std.Dev)	7	3
Age (Min & Max)	2	14
BMI-for-Age		
normal	102	87.9
obese	2	1.7
overweight	3	2.6
underweight	9	7.8
BMI		
Mean-Std, Dev	16	2
Min - Max	13	21
Height		
Mean-Std, Dev	121	18
Min - Max	78	165
Injury Etiology		
Fall	110	95
Road traffic accident	1	1
Sport	4	3
Assault	1	1
Place of injury		
School	65	56
Home	49	42
Public play ground	1	1
Road	1	1
Laterality		
Right	57	49
Left	59	51

Table 1.0: patient and injury demographic

A total of 116 participants were recruited in this study. Majority of the participants were of male gender (n = 80 (69%)). The mean injury age was 7 years with a range of 2 to 14 years. Majority of the elbow injuries occurred in the 6-8year age group (n = 36 (31%)). The mean BMI was 16 kg/m^2 (range 13-21 Kg/m^2) and the mean height of the participants was 121cm (range 78-165cm). The main cause of injury was fall (n = 110 (95%)) followed by sports related activities (3%). Road traffic accidents and assaults at 1% each.

Majority of the injuries occurred at school (n = 65 (56.0%)) followed by injuries at home and its surroundings (42.2%). Public playground injuries and road side injuries comprised 0.9% each.

The left elbow was injured more than the right (n = 59(51%)).

Fracture Distribution

Table 1.1 Distribution of elbow fractures by age groups

		Age of the patient											
		Total		0 – 2		3 – 5		6 – 8		9 – 11		>11	
		n	%	n	%	n	%	n	%	n	%	n	%
	Total	116	100%	6	100%	30	100%	36	100%	27	100%	17	100%
Supracondylar	Gartland 1	38	33%	5	83%	14	47%	13	36%	5	19%	1	6%
	Gartland 2	40	34%	0	0%	10	33%	18	50%	9	33%	3	18%
	Gartland 3	12	10%	1	17%	5	17%	2	6%	4	15%	0	0%
Other elbow fractures	Lateral Humerus Condyle	8	7%	0	0%	1	3%	1	3%	3	11%	3	18%
	Medial epicondyle	7	6%	0	0%	0	0%	0	0%	3	11%	4	24%
	Radial neck	4	3%	0	0%	0	0%	1	3%	0	0%	3	18%
	Olecranon	5	4%	0	0%	0	0%	1	3%	3	11%	1	6%
	Lateral epicondyle	2	2%	0	0%		0%	0	00%	0	0%	2	12%

Supracondylar humeral fracture was the predominant fracture pattern (77%), followed by lateral condyle fracture (7%) and medial epicondyle (6%) fracture was third. Other elbow fractures included olecranon fractures (4%), radial neck fractures (3%) and lateral epicondyle (2%).

Most common supracondylar fracture was Gartland 2 (34%) followed by Gartland 1 (33%) and Gartland 3 (10%).

Supracondylar fractures were common in the 6-8 year age groups(n=33) closely followed by 3-5 year age group(n=29). Other elbow fractures mainly affected older children 9-14 age groups.

Table 1.2 Type of elbow fracture versus BMI-Percentile-Age.

Category	BMI			
Fracture types	**Underweight**	**Normal**	**Overweight**	**Obese**
Supracondylar	6	80	2	2
Lateral condyle	2	6	0	0
Medial epicondyle	0	7	1	0
Radial neck	1	3	0	0
Olecranon	0	4	0	0
Lateral epicondyle	0	2	0	0

Table 1.2 shows the type of fracture in relation to the body weights of the patients, we found that supracondylar humerus fracture was the most common elbow fracture. Most of the participants fell in the 'normal' BMI percentile. The two obese patients had supracondylar Gartland 3.

Mechanism of injury

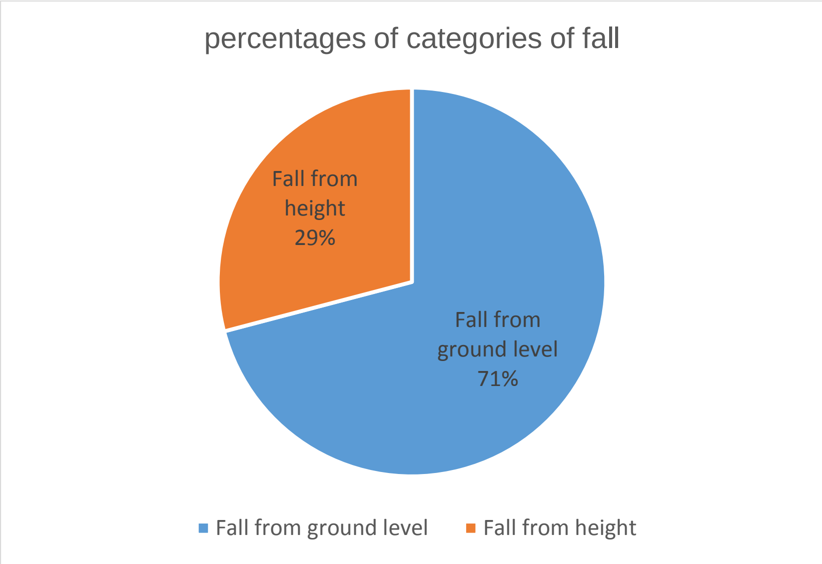
Table 1.3 Mechanism of injury versus Prevalence

		Total	
		Count	Percentage
Mechanism of Injury	Total	116	100%
	Fall	110	95%
	Road traffic accident	1	1%
	Sport	4	3%
	Assault	1	1%

Table 1.4 Mechanism of injury by sex

	Total		Male		Female	
	n	%	n	%	n	%
Total	116	100%	80	100%	36	100%
Fall	110	95%	74	93%	36	100%
Road traffic accident	1	1%	1	1%	0	0%
Sport	4	3%	4	5%	0	0%
Assault	1	1%	1	1%	0	0%

Figure 1.0 Percentage of different categories of fall



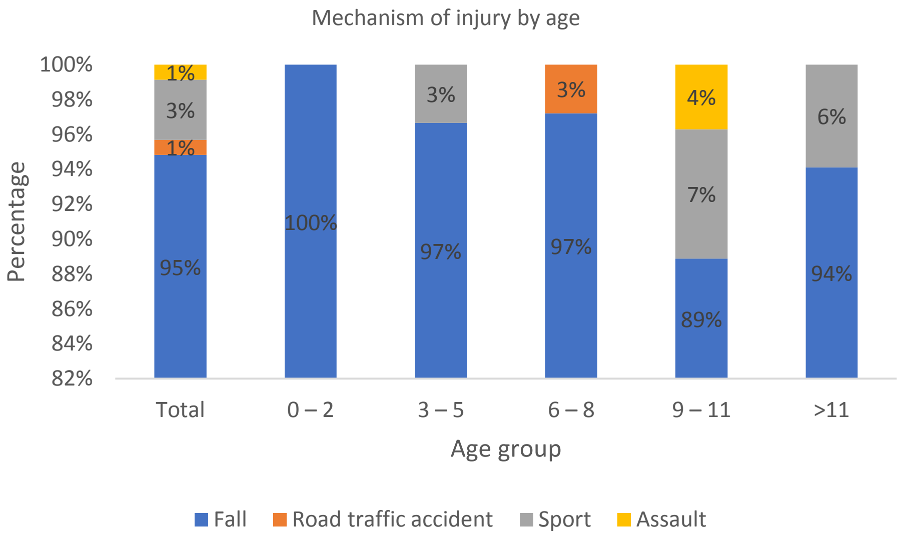
Fall was the predominant mechanism of injury in both sexes affecting boys more than girls. Fall from ground level(71%) was the commonest followed by fall from a height(29%). Sports related injuries and RTAs affected boys.

Table 1.5 Mechanism of injury by age group.

		Age of the patient											
		Total		0 – 2		3 – 5		6 – 8		9 – 11		>11	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Mechanism of injury	Total	116	100%	6	100%	30	100%	36	100%	27	100%	17	100%
	Fall	110	95%	6	100%	29	97%	35	97%	24	89%	16	94%
	Road traffic accident	1	1%	0	0%	0	0%	1	3%	0	0%	0	0%
	Sport	4	3%	0	0%	1	3%	0	0%	2	7%	1	6%
	Assault	1	1%	0	0%	0	0%	0	0%	1	4%	0	0%

Table 1.5 the most common mechanism of injury was a fall mainly affecting the 3- 14 year age group. Sports related injuries were the second most common mainly affecting 9-11 year age group.

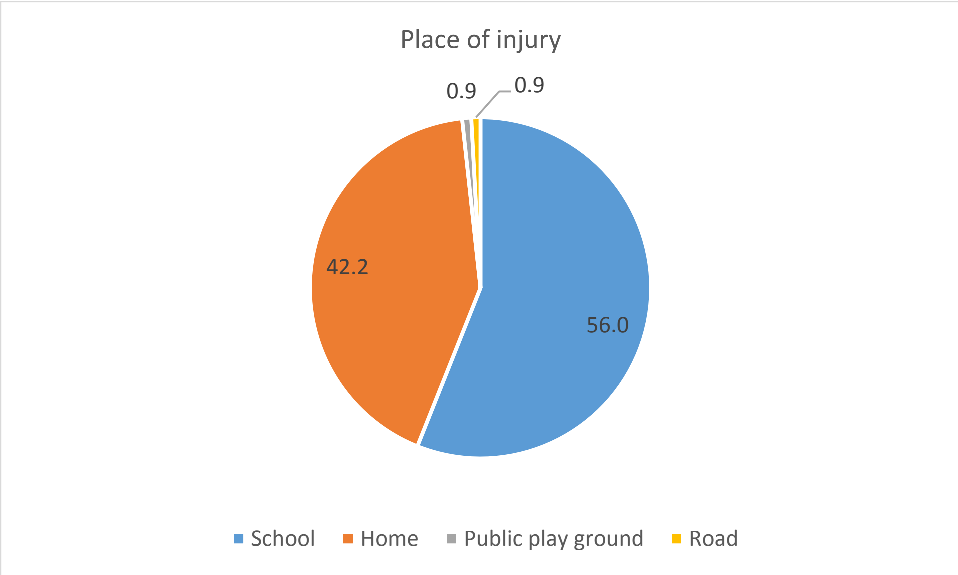
Figure1.1 Mechanism of injury by age group



Major etiology of the elbow injuries across all age groups was fall (90%). Sports related injuries mainly occurred in older children 9-14 age group.

Place of injury.

Figure 1.2 Pie chart showing percentages on the place of injury



Most of the elbow fractures occurred in school (56%), followed by injuries occurring at home (42.2%). Public playground accidents and injuries occurring by the roadside comprised 0.9% each.

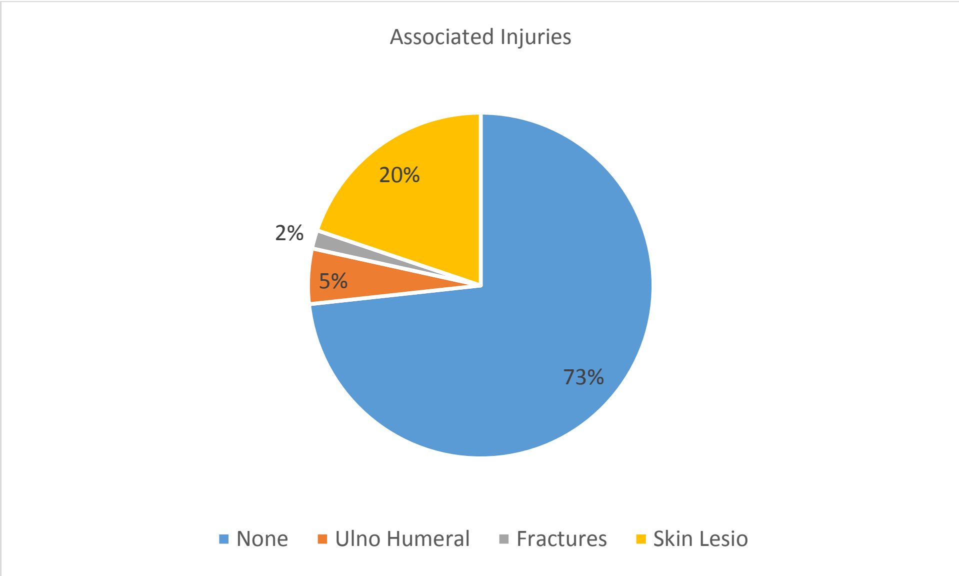
Table 1.6 Table showing age, gender versus where the injury occurred

		Place where injury occurred									
		Total		School		Home		Public play ground		Road	
		n	%	n	%	n	%	n	%	n	%
gender of participant	Total	116	100%	65	100%	49	100%	1	100%	1	100%
	Male	80	69%	40	62%	38	78%	1	100%	1	100%
	Female	36	31%	25	38%	11	22%	0	0%	0	0%
Age of the patient	Total	116	100%	65	100%	49	100%	1	100%	1	100%
	0 – 2	6	5%	0	0%	6	9%	0	0%	0	0%
	3 – 5	30	26%	17	26%	13	27%	0	0%	0	0%
	6 – 8	36	31%	22	34%	13	27%	0	0%	1	100%
	9 – 11	27	23%	14	22%	12	24%	1	100%	0	0%
	>11	17	15%	6	9%	11	22%	0	0%	0	0%

Most injuries occurred at school (56%) followed by home (42%). Majority of the children injured at school were in the (6-8) year age group. Injuries occurring at home were almost equal amongst all age groups apart from 0-2 years (9%) who were least likely to be injured in that setting. Public playground injuries and road side injuries constituted 0.9% each.

Associated injuries

Figure 1.3 Associated injuries



Elbow fractures with associated injuries constituted 27% of all cases. The most common lesion was skin lesions that comprised of abrasion, blisters and lacerations (20%). Elbow dislocation in addition to the elbow fracture was present in 5% of cases and ipsilateral forearm fractures were present in 2% of the elbow fractures

Table 1.7: Elbow fracture type vs associated injuries

		ASSOCIATED_INJURIES									
		Total		**None**		**Ulno Humeral dislocation**		**Fractures (ipsilateral upper limb)**		**Skin Lesions**	
		n	%	n	%	n	%	n	%	n	%
	Total	116	100%	85	100%	6	100%	2	100%	26	100%
Supracondylar	Gartland 1	38	33%	36	42%	0	0%	0	0%	2	8%
	Gartland 2	40	34%	33	39%	0	0%	0	0%	7	27%
	Gartland 3	12	10%	8	9%	0	0%	1	50%	3	12%
Other elbow fractures	Lateral Humerus Condyle	8	7%	3	4%	2	33%	0	0%	5	19%
	Medial epicondyle	7	6%	4	5%	1	17%	0	0%	3	12%
	Radial neck	4	3%	0	0%	3	50%	0	0%	3	12%
	Olecranon	5	4%	0	0%	0	0%	1	50%	3	12%
	Lateral epicondyle	2	2%	1	1%	0	0%	0	0%	0	0%

Table 1.8 Percentage of closed versus open fractures and associated injuries

		Frequency	Percentage
Type of fracture	Closed	113	97.4%
	Open	3	2.6%
	Total	116	100.0%
Associated Injuries	None	85	73.3%
	Ulno Humeral Dislocation	6	5.2%
	Fractures (Ipsilateral Upper limb)	2	1.7%
	Skin Lesions	23	19.8%
	Total	116	100.0%

Table 1.8; The predominant associated lesion were skin lesions (19.8%) followed by elbow dislocation at 5.2 percent and ipsilateral fractures at 1%.skin lesion were mostly associated with supracondylar fractures. Elbow dislocation were associated with radial neck, olecranon and lateral epicondyle fractures.

Closed fractures were 97.4%and open fractures 2.6%. The frequency of fracture severity as per the Gartland classification is as follows Gartland 1(34%), Gartland 2 (45%)and Gartland 3 (17%).All were extension type fractures no flexion type were recorded.

Table 1.9 Analyses of association between BMI and Supracondylar

Determining risk factors for Supracondylar severity

Univariate Ordered Logistic regression

Variables	**Odds Ratio (95% CI)**	**P-value**
Age	1.187463 (1.059483 - 1.330903)	**0.003***
Sex	1.417357 (.6780259 - 2.962867)	0.93
Height	1.032634 (1.011686 - 1.0540160)	**0.002***
Weight	1.074007 (1.025731 - 1.124556)	**0.002***
BMI	1.228055 (.9739922 1.54839)	0.082

*OR, odds ratio. *Bold figures indicate significant association with severity of supracondylar at 95% CI.*

Univariate logistic regression results (Table 1.9) indicated that age OR (1.187463 (1.059483 - 1.330903)) P-value 0.003 was a positive covariate of supracondylar fracture severity as well as height OR (1.032634 (1.011686 - 1.0540160)) P-value 0.002 and weight OR (1.074007 (1.025731 - 1.124556)) P-value 0.002. This implies that a unit rise in age, height and weight increases the likelihood of sustaining a supracondylar Gartland 3 fracture as compared to Gartland 1. There was no association between supracondylar fracture severity and sex (P-value 0.93) and BMI (P-value 0.082).

Table 2.0 Multivariate Logistic regression for Fracture severity

Variables	Odds Ratio (95% CI)	P-value
Age	1.005739 (.7157017 1.413312)	0.974
Height	1.020463 (.9503748 1.09572)	0.577
Weight	1.02613 (.8748008 1.203636)	0.751

Notes: Controlled for BMI and Sex (confounder

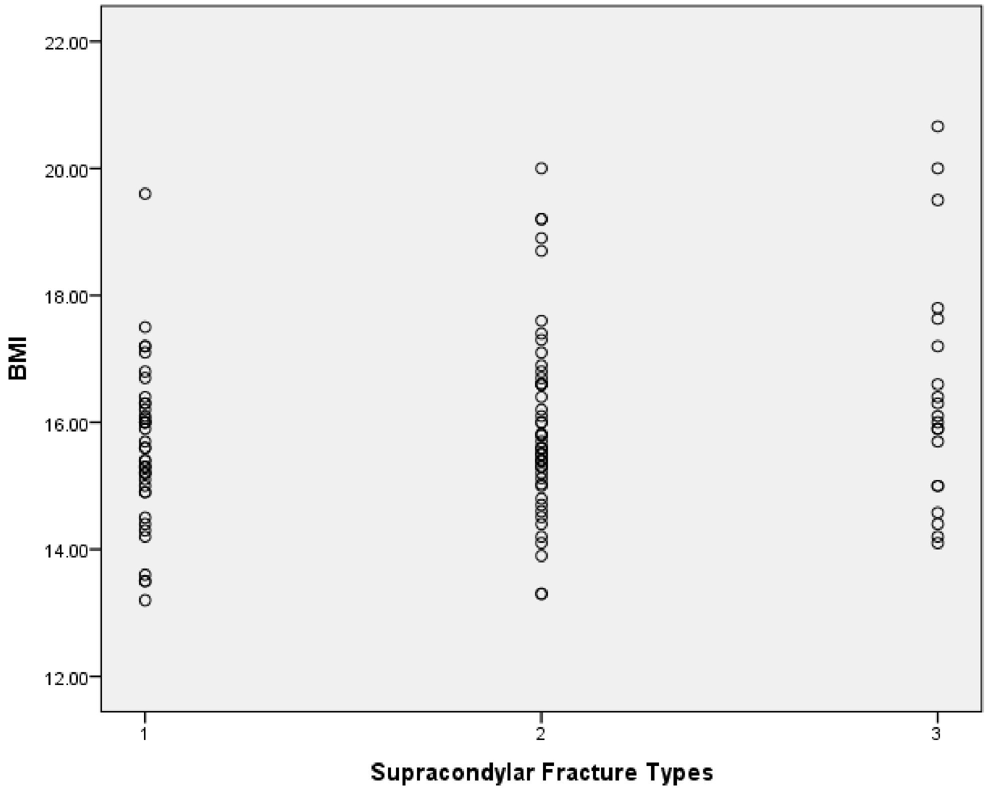
Multivariate regression analysis (Table 2.0) of the positive factors in univariate analysis controlled for confounders sex and BMI showed no association between age, height or weight with supracondylar fracture severity. Overall this implies that supracondylar fracture severity is not independently influenced by BMI or its constituents age, weight or height.

Table 2.1 Supracondylar fracture types versus BMI percentiles.

Category	**Supracondylar Types**			
BMI	**1**	**2**	**3**	**p-value**
Underweight	3	5	1	1.000
Normal	36	46	16	0.523
Overweight	1	1	1	0.767
Obese	0	0	2	**0.031**

Table 2.1 Most of the fractures were in the 'normal' BMI percentile with five patients in the overweight and obese categories. Two patients in the obese category had Gartland type 3 fracture (p=0.031).

Figure 1.4 A scatter plot summary of supracondylar fracture types versus BMI



Majority of the fractures were gartland type 2 with majority of the children's BMI falling between 14-18 kg/m2. This corresponds to the normal BMI percentile. Few outliers with BMI above 20kg/m2 mostly in gartland type 3 fractures.

8 DISCUSSION

The aim of this study was to determine the pattern of elbow fractures in children and association between BMI and pediatric elbow fractures at a major referral hospital in Kenya. Supracondylar fracture is by far the most common fracture of the elbow in children with figures ranging between 40 and 70% of cases(58).

According to this study supracondylar fracture was the most common at (77%) followed by lateral condyle fracture (8%) and the third being medial epicondyle (6%)(table 1.1), this is similar to other studies conducted in other regions (5,8,33,39).

Supracondylar is common between age 3-8 years. This peak is thought to be associated with the fact that capsule and ligament supporting the elbow have a greater tensile strength than bone itself which leads to preferential fracture of the vulnerable supracondylar region when sufficient force is applied.

In terms of place of injury most elbow injuries occurred in school (56%) followed by home and its environs (42%). Injuries occurring at public playground and injuries occurring by the roadside comprised 0.9%(Fig 1.2). This is in contrast to other studies which showed that majority of injuries occurred at home(4,8,33). This can be explained by the fact that the peak data collection period coincided with school going period where children spend most of their day in school as compared to school holiday. A local study done in 2011 evaluating causes of accidents among young children in Kenyan schools found that the high incidence of injuries were due to human errors specifically children rough play/indiscipline, inadequate supervision and poor condition of classroom & play facilities and their wrong use (59). In this study infants and toddlers were injured at home following falls from furniture while school going children of age between 3-11 years were injured at school (table 1.6).

Most injuries occurred in boys (69%) as compared to girls (31%) with a M:F ratio of 2.2:1 as seen in table 1.0. Generalized male predominance is probably due to the experimenting and risk-taking behavior that is more common in males. The left elbow was injured more commonly than the right. This is similar to other studies (5,7,8,10,39,41).

The mechanism of injury varies, but the most commonly described mechanism involves a fall on an outstretched hand with varus, valgus or rotational force or a combination thereof. The vectors of force and the degree of chondro-osseous development dictate the type of injury incurred. In the extended position, the olecranon becomes locked in the olecranon fossa of the distal humerus, levering against the margins of the fossa. Fall constituted the major mechanism of injury in our study at (95%). Majority were due to ground level fall during playing/running (71%) followed by fall from a height (29%) (fig 1.0). Second most common was due to sporting activity (4%), this mainly involved contact sports especially football. Road traffic accident comprised 1%.The low RTA percentage was similar to a study conducted in Ethiopia(10).According to a local study on patterns of pediatrics long bone fractures(4). There was one case of non-accidental trauma resulting in an elbow fracture after the child was 'hit with a stick' by his guardian (table 1.4).

Associated injuries accounted for 26.7% of cases. The soft tissue lesions were noted in 19.8% of cases (Table 1.8). These lesions were mostly blisters and skin abrasions which were mainly observed in supracondylar fractures. There was one case of nerve injury which involved the radial nerve. Elbow fractures were associated with other bone lesions in 1.7% of cases. It was associated in 2 cases with a floating elbow which involved a complete both radius and ulna midshaft fractures and in the other case a fracture of the distal quarter of the radius at the epiphyseal region. Elbow dislocations were seen in 5.2% of cases and were associated with lateral condyle, medial epicondyle and radial neck fractures. This was similar to a study conducted in Senegal (7).

The mean BMI-for-age percentile in the current study population fell into the normal range (less than 85%) at 87.9% of participants, with 1.72% of patients considered obese (Table 1.0). The low rates of obesity are consistent with 2014 Kenya Demographic and Health survey that puts the percentage of overweight and obese children at four percent(60). According to the Centers for Disease Control and Prevention, overweight and obese children tend to be less physically active (61). Because most of these fractures were sustained during physical activity, it is logical that most of the current patients sustaining elbow fractures had normal BMIs. The most frequent injury mechanism (fall) was consistent with other literature (4,7,8,10,33).

An analysis of different elbow fractures in relation to BMI showed that majority of the children with elbow fractures fell within the normal BMI percentile (88%) with children in the overweight and obese categories comprising about 4.3%. Due to low numbers in the underweight, overweight and obese categories, association between all elbow fractures and BMI could not be analyzed.

Sub group analysis of supracondylar humerus fractures severity in relation to BMI showed that more obese patients sustained gartland 3 fractures as compared to gartland 1 and 2 fractures($p=0.031$) (Table 2.1).

There was no correlation between the gartland fracture types and degree of obesity ($r=0.152$, $n=116$, $p=0.108$).

As regards to the relationship between BMI and supracondylar fracture severity in this study, an ordered univariate regression analysis of age, sex, height and weight was done. Results showed a significant association between age OR 1.187 (1.059-1.3309) p-value 0.003, height OR 1.032634 (1.011686-1.0540160) p-value 0.002 and weight OR 1.074007 (1.025731-1.124556) p-value 0.002 at 95% confidence interval (Table 1.9). In this study, there was a positive correlation between increasing age and severe supracondylar fracture occurrence p-value (0.003) on univariate regression analysis. Bone composition changes with growth. It is well established that the bones of an older child has less collagen, thinner periosteal sleeve and cancellous bone compared to a younger child(62). This implies that older children will fracture more readily, and their fractures are more likely to be comminuted rather than a simple two part fracture. Compared with younger children, older children are larger in stature, heavier and more likely to participate in strenuous activities and sports that often involve greater heights and speeds. As such, older children may sustain higher energy injuries compared with those sustained by their younger counterparts hence more severe elbow injuries. Changes in bone composition and higher energy injuries in older children may at least in part explain this finding.

Height was another significant covariate in univariate logistic regression on supracondylar fracture severity. Increasing height predisposed one to a more severe elbow fracture p-value 0.002. Jones et al in his study showed that taller height during childhood is associated with increased rates of wrist and other upper extremity fractures. During rapid growth periods, corresponding increased bone remodeling results in decreased bone mineral density(63). Decreased bone mineral density in a pediatric patient results in a weakened, fracture prone skeletal fracture(64). As height increases, so does the force at which a patient lands on an outstretched arm. It is this force, translated to the distal humerus, that is ultimately responsible for supracondylar fractures(65). Studies have also demonstrated that larger children are more likely to fall and sustain a fracture since the rate of bony growth seem to outpace the development of coordination and balance(66).

Increase in weight was also associated with supracondylar fracture on univariate analysis with OR (1.074007 (1.025731 - 1.124556)) P-value 0.002. This implies that there is a linear relationship between weight gain and incidence of having a supracondylar humeral fracture. A higher fracture risk in obese children may be the result of greater forces generated during a fall, a lifestyle contraindicative to strong bones and/or excess fat tissue that impairs bone strength development (16). In one study Seeley found that obese children had a higher rate of complex fracture pattern, nerve palsies and postoperative complications as compared to normal weight children (23). His study supports the idea that as body mass increases, so does the force generated from a comparable mechanism of injury, thus leading obese children to sustain more severe injury patterns than their non obese peers.

There was no association with sex and BMI with p-values of 0.93 and 0.082 respectively. This shows an increased incidence of supracondylar fracture severity in relation to age as well as height and weight on univariate analysis.

On multivariate logistic regression for age, height and weight controlled for BMI and sex in relation to supracondylar fracture severity, no significant association was seen with p-values of 0.974,0.577 and 0.751 respectively. This study had a smaller sample size compared to other studies and the population of obese and overweight children was small. Most of the participants were in the normal percentile, therefore association between obesity and supracondylar severity could not be definitively established. This study was similar to Michelson's (67) who found children sustaining supracondylar Gartland type 3 fractures were significantly older and taller than those sustaining Gartland 1 and 2 but no significant difference existed between sexes, BMI and BMI-for-age percentile.

Conclusion

Majority of elbow fractures are supracondylar humeral fractures followed by lateral condyle fractures and medial epicondyle fractures respectively. Majority of the elbow injuries occur in the school setting with the most common mechanism of injury being fall from ground level. The peak age of injury is between 3-8 years. Body mass index and BMI-for-age percentile have no association with supracondylar fracture severity.

Recommendations

Enhanced school supervision to decrease incidence of elbow injuries occurring at school.

Implementation of guidelines on the use of playgrounds may lead to the reduction of injuries associated with playground equipment.

Guidelines for athletic/professional sporting activities coupled with the use of protective gear may also reduce injuries at school or during sporting activities.

STUDY LIMITATIONS

Our study had several limitations the study duration was not long enough to determine effects of changes in climatic seasons and/school holidays seasons on elbow fracture occurrence.

The study was carried out in a referral hospital which mainly caters for low and middle socio-economic status which has an influence in the overweight and obesity population.

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10. APPENDICES

10.1 APPENDIX I

PARTICIPANT INFORMATION AND CONSENT FORM

PARENTAL CONSENT

Title of Study: PATTERN OF PEDITRIC ELBOW FRACTURES AND ASSOCIATION WITH BODY MASS INDEX.

Principal Investigator \ and institutional affiliation: DR KENNETH KIARIE MWAURA. H58/74849/2014.

Registrar University of Nairobi, School of Nairobi, Department of Orthopedic Surgery.

Introduction:

I would like to tell you about a study being conducted by the above listed researcher. The purpose of this consent form is to give you the information you will need to help you decide whether or not your child should participate in the study. Feel free to ask any questions about the purpose of the research, what happens if your child participates in the study, the possible risks and benefits, the rights of your child as a volunteer, and anything else about the research or this form that is not clear. When we have answered all your questions to your satisfaction, you may decide if you want your child to be in the study or not. This process is called 'informed consent'. Once you understand and agree for your child to be in the study, I will request you to sign your name on this form. You should understand the general principles which apply to all participants in a medical research: i) Your child decision to participate is entirely voluntary ii) You may withdraw your child from the study at any time without necessarily giving a reason for his/her withdrawal iii) Refusal to participate in the research will not affect the services your child is entitled to in this health facility or other facilities.

May I continue? YES / NO

For children below 18 years of age we give information about the study to parents or guardians. We will go over this information with you and you need to give permission in order for your child to participate in this study. We will give you a copy of this form for your records.

If your child is 6 years of age or older, he/she will also be required to agree to participate in the study after being fully informed.

WHAT IS THE PURPOSE OF THE STUDY?

The researcher listed above is interviewing individuals who sustained a fracture around their elbow after trauma. Participants in this research study will be asked questions about events/circumstances that lead to the injury such as place and activity involved. Participants will also have the choice to undergo a physical exam of the injured extremity to look for other associated injuries related to the elbow fracture. There will be approximately 73 participants in this study randomly chosen. We are asking for your consent to consider your child to participate in this study.

WHAT WILL HAPPEN IF YOU DECIDE YOU WANT YOUR CHILD TO BE IN THIS RESEARCH STUDY?

If you agree for your child to participate in this study, the following things will happen: You will be interviewed by a trained interviewer in a private area where you feel comfortable answering questions. The interview will last approximately ten minutes. The interview will cover topics such as your child's age, date and time of injury, place of injury and event that caused the injury.

After the interview has finished your child's weight and height will be taken and a gentle physical exam of the injured upper extremity will be conducted to look for associated injuries of the elbow like other fractures, vascular and nerve injuries. An X-ray9plain radiographs) of the injured elbow or other areas of the upper limb as determined by the physical exam will be carried out and will be used to classify the elbow injury.

We will ask for a telephone number where we can contact you if necessary. If you agree to provide your contact information, it will be used only by people working for this study and will never be shared with others. The reasons why we may need to contact you include to verify additional information not captured in the questionnaire or follow up of the child in the event of a complication related to the injury.

ARE THERE ANY RISKS, HARMS, DISCOMFORTS ASSOCIATED WITH THIS STUDY?

Medical research has the potential to introduce psychological, social, emotional and physical risks. Effort should always be put in place to minimize the risks. One potential risk of being in the study is loss of privacy. We will keep everything you tell us as confidential as possible. We will use a code number to identify your child in a password-protected computer database and will keep all of our paper records in a locked file cabinet. However, no system of protecting confidentiality can be absolutely secure so it is still possible that someone could find out your child was in this study and could find out information about your child. Also, answering questions in the interview may be uncomfortable for you. If there are any questions you do not want to answer, you can skip them. You have the right to refuse the interview or any questions asked during the interview.

It may be embarrassing for you to have to undress your child in order to examine the entire upper extremity from finger to the clavicle. We will do everything we can to ensure that this is done in private. Furthermore, all study staff and interviewers are professionals with special training in these examinations/interviews.

Your child may feel some discomfort during the physical exam. We will conduct the exam as gently and humanely as we can after adequate pain control. In case of an injury, illness or complications related to this study, contact the study staff right away at the number provided at the end of this document. The study staff will treat your child for minor conditions or refer the child for treatment for conditions that require more extensive care.

ARE THERE ANY BENEFITS BEING IN THIS STUDY?

This research study has no direct benefits but the information obtained will help us better understand elbow fractures in children , develop prevention strategies and improve quality of care in children who sustain these injuries.

WILL BEING IN THIS STUDY COST YOU ANYTHING?

No payment will be required for your child to be a participant in the study.

IS THERE REIMBURSEMENT FOR PARTICIPATING IN THIS STUDY?

Transport cost will be fully reimbursed in the unlikely event that that the principal investigator may need to review your child again.

WHAT IF YOU HAVE QUESTIONS IN FUTURE?

If you have further questions or concerns about your child participating in this study, please call or send a text message to the study staff at the number provided at the bottom of this page.

For more information about your child's rights as a research participant you may contact the Secretary/Chairperson, Kenyatta National Hospital-University of Nairobi Ethics and Research Committee Telephone No. 2726300 Ext. 44102 email uonknh_erc@uonbi.ac.ke.

The study staff will pay you back for your charges to these numbers if the call is for study-related communication.

WHAT ARE YOUR OTHER CHOICES?

Your decision to have your child participate in this research is voluntary. You are free to decline or withdraw participation of your child in the study at any time without injustice or loss of benefits. Just inform the study staff and the participation of your child in the study will be stopped. You do not have to give reasons for withdrawing your child if you do not wish to do so. Withdrawal of your child from the study will not affect the services your child is otherwise entitled to in this health facility or other health facilities.

For more information contact Dr Kenneth Kiarie Mwaura at University of Nairobi, school of medicine. Department of Orthopedic Surgery Telephone number 0723913148 from

Daily from 7am to 8pm.

CONSENT FORM (STATEMENT OF CONSENT)

The person being considered for this study is unable to consent for him/herself because he or she is a minor (a person less than 18 years of age). You are being asked to give your permission to include your child in this study.

Parent/guardian statement I have read this consent form or had the information read to me. I have had the chance to discuss this research study with a study counselor. I have had my questions answered by him or her in a language that I understand. The risks and benefits have been explained to me. I understand that I will be given a copy of this consent form after signing it. I understand that my participation and that of my child in this study is voluntary and that I may choose to withdraw it any time.

I understand that all efforts will be made to keep information regarding me and my child's personal identity confidential.

By signing this consent form, I have not given up my child's legal rights as a participant in this research study.

I voluntarily agree to my child's participation in this research study:

Yes No

I agree to have my child undergo a complete physical exam:

Yes No

I agree to provide contact information for follow-up:

Yes No

Parent/Guardian signature /Thumb stamp: _______________

Date ____________________

Parents/Guardian printed name: ________________________________

Researcher's statement I, the undersigned, have fully explained the relevant details of this research study to the participant named above and believe that the participant has understood and has knowingly given his/her consent.

Printed name___________________________

Date: _________________________

Signature: __________________________________

Role in the study: _________________________________

IDHINI YA KUSHIRIKI KATIKA UTAFITI YA MZAZI/MLEZI.

Mtafiti: Dkt. Kenneth Kiarie Mwaura, Idara ya upasuaji wa mifupa, Chuo kikuu cha Nairobi

Maelezo kuhusu utafiti huu:

Lengo kuu la utafiti huu ni kuchunguza majeraha yanayotokea katika kiwiko na mifupa ya mikono ya watoto. Tunataka kuchunguza mahali majeraha haya yanapofanyika, kisa kinacho sababisha majeraha na majeraha mengine yanayotokana na kuvunjika mifupa ya kiwiko. Uwezekano wa uhusiano kati ya majeraha haya na uzito wa mwili utabainishwa. Utafiti huu utasaidia katika kuweka mipango bora ya kuzuia majeraha haya, na pia kuweka mikakati ya kutibu hawa watoto vyema.

Utahitajika kufanya nini?

Ukikubali mwanawe awe katika utafiti huu, utajaza dodoso ya maswali kuhusu mahali na kisa kilicho sababisha majeraha haya. Mtafiti mkuu au wasaidizi wake watapima kimo na uzito wa mwanawe. Mkono mzima utachunguzwa kutafuta majeraha zaidi. Picha aina ya x-rays itakayoonyesha mfupa uliovunjika itachunguzwa ili kubaini umevunjikia wapi.

Usiri:

Taarifa yeyote utakayotupea tutaiweka kisiri na itatumiwa kwa utafiti huu pekee. Majina au taarifa yeyote inayoweza kuvumbua utambulisho wako au wa mwanawe haitawekwa katika matokeo yetu.

Hakuna madhara

Utafiti huu hauna madhara yeyote ya kiafya kwa mwanawe yanayotarajiwa.

Kukataa kushiriki

Una haki ya kukataa mwanawe kutoshiriki katika utafiti. Una haki na uhuru wa kumwondoa mwanawe katika utafiti huu wakati wowote ule unapotaka. Huduma ambayo mtoto wako atapata haitaadhirika kwa vyovyote vile.

Mawasiliano:

Ukiwa una swali, unaweza wasiliana na:

Dkt. Kenneth Kiarie Mwaura
Nambari ya simu: 0723913148.
Barua pepe: Kennethmwaura@yahoo.com

AMA
Mwenyekiti,
UON/KNH Maadili na kamati ya Utafiti, Numbari ya simu: 020-2726300 Ext. 44355

Nimesoma vilivyo na kuelewa maelezo yote yaliyohapa na maswali yangu yote yamejibiwa kikamilifu.

Mimi kwa hiari nakubali kuandikisha mtoto wangu katika utafiti huu

Jina la mgonjwa: ____

Jina la mzazi/mlezi: _____________________________________

Sahihi ya mzazi/mlezi:____________________Tarehe: ______

Assent Form

Project Title: Pattern of pediatric elbow fracture and association with body mass index.

My name is Dr. Kenneth Kiarie Mwaura I am doing a research study about elbow fractures in children. Permission has been granted to undertake this study by the Kenyatta National Hospital- University of Nairobi Ethics and Research Committee (P247/03/2019).

This research study is a way to learn more about children and injuries they sustain. At least 73 children will be participating in this research study with you. If you decide that you want to be part of this study, you will be asked to describe what happened leading to your injury. We will also look at your x-ray films to see how the bones are broken. We will show you where the bone is broken. We will also examine the broken area to look for any wounds. This will be done as gently as possible so as to cause as little discomfort to you as possible.

You will not benefit from this study immediately. A benefit means that something good happens to you. We think this study will benefit you and other children in future by helping us come up with ways of preventing injuries like the one you have. It will also help us develop better ways of attending to children with similar injuries to yours.

When we are finished with this study, we will write a report about what was learned. This report will not include your name or that you were in the study. You do not have to be in this study if you do not want to be. If you decide to stop after we begin, that is okay too. Your parents know about the study too. If you decide you want to be in this study, please sign your name.

I____ want to be in this research study.

______________________________ (Signature/Thumb stamp)

______________________________(Date)

Kukubali Kushiriki katika Utafiti

Jina langu ni Dkt. Kenneth Kiarie Mwaura Ninafanya utafiti kuhusu watoto waliovunjika mifupa ya mikono (Kiwiko). Utafiti huu utatusaidia kujua jinsi ulivyovunjika. Kuna watoto wengine hamsini na mbili hivi ambao wanashiriki katika utafiti huu.

Ukukubali kushiriki katika utafiti huu, utatueleza kuhusu ulivyo vunjika na kama umeshawahi vunjika tena. Aidha tutaangalia picha yako ya x-ray ili kubaini vile mifupa imuevunjika. Tutaweza kukuonyesha pale palipo vunjika.

Utafiti huu hutakuwezesha kupata manufaa yoyote saa hii lakini baadaye utanufaishi watoto wengine na wewe kwa kutusaidia kupata njia nzuri za kuzuia majeraha kama uliyoyapata. Pia itatuwezesha kutafuat nji bora za kuhudumia waliojeruhiwa.

Tukimaliza utafiti huu, tutatoa ripoti. Hii ripoti haitakuwa na jina lako aidha kama ulishiriki katika utafiti huu. Unaweza kuamua kutoshiriki sasa ama wakati wowote katika utafiti huu. Hii haitaadhiri matibabu ambayo unayoyapata au utakayoyapata baadaye. Kama umekubali kushiriki, tafadhali tia sahihi hapa chini.

Mimi ______________________________nimekubali kushiriki katika huu utafiti,

_________________________Sahihi/alama ya kidole gumba

__________________________Tarehe

10.2 APPENDIX II

DATA COLLECTION SHEET.

Biodata

Hospital Number: Study Number:

X-ray Number: Date of interview**:**

Please fill in the following details:

Patient's Details

1. Age: …………Years…………………. Months
2. Sex: ☐ Male ☐ Female
3. Weight…………. (kgs) Height/length………….. (cms)

   BMI............ BMI Percentile for age/sex………………….
4. Residence: County………………………Town/village……………..
5. Date of Injury: ……. /………/2019.

   Time of injury……………………………..

Parent/Guardian's Details:

6. Relation: …...………………………………………………………….
7. Phone number: ………………………………………………………

Injury Details:

8. Where did the injury happen?

☐ Home

☐ At school

☐ Public playground

☐ Road

☐ Other (specify)………………………………

9. Elbow injured:

☐ Left ☐ Right

10. Hand dominance (where applicable):

☐ Left ☐ Right

11. Pattern of elbow fracture:

	Gartland classification	
1. Supracondylar Humerus fracture	Gartland 1	☐
	Gartland 2	☐
	Gartland 3	☐
Flexion type		☐

2. Lateral Humerus condyle fracture ☐
3. Medial epicondyle fracture ☐
4. Radial neck fracture ☐
5. Radial head fracture ☐
6. Olecranon fracture ☐
7. Coronoid fracture ☐
8. Lateral epicondyle fracture ☐
9. Medial condyle fracture ☐

10. Intercondylar fracture ☐
11. T or Y humerus fracture ☐
12. Montegia fracture ☐
13. Capitellum fracture ☐

Mechanism of Injury

12. How did the he/she sustain the fracture?

a) **Fall:** ☐ Yes ☐ No

If yes ☐ Ground level ☐ Height

Specify ……………………………………………………………

b) **Road Traffic Accident:** ☐ Yes ☐ No

If yes ☐ Pedestrian

☐ Passenger (car)

☐ Pillion (motor bike)

Specify ……………………………………………………………

c) **Sport:** ☐ Yes ☐ No

If yes ☐ Contact sport ☐ Non -contact sport

Specify …………………………………………………………….

d) **Assault:** ☐ Yes ☐ No

If yes specify ………………………………………………………...

e) **Others** (specify) …………………………………………………….

13. **<u>Associated injuries</u>**

1) Dislocation ☐ Yes ☐ No
   (Ulno humeral)

2) Fractures ☐ Yes ☐ No
   If Yes specify
   ……………………………………………………………………..

3) Skin lesion ☐ Yes ☐ No

4) Are/Is the fracture(s) ☐ Closed ☐ Open

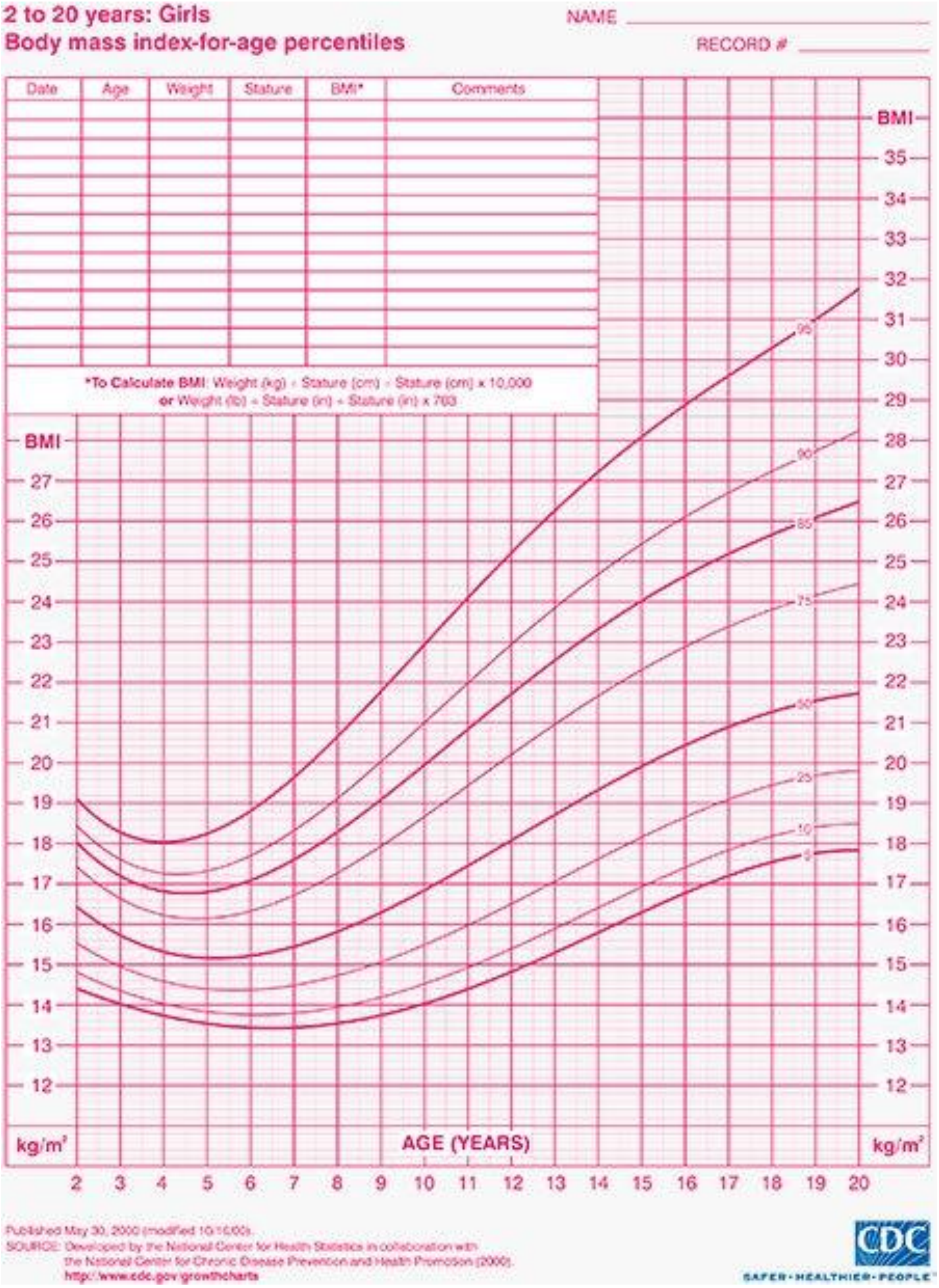
14. Vascular Assessment (*tick where appropriate*)

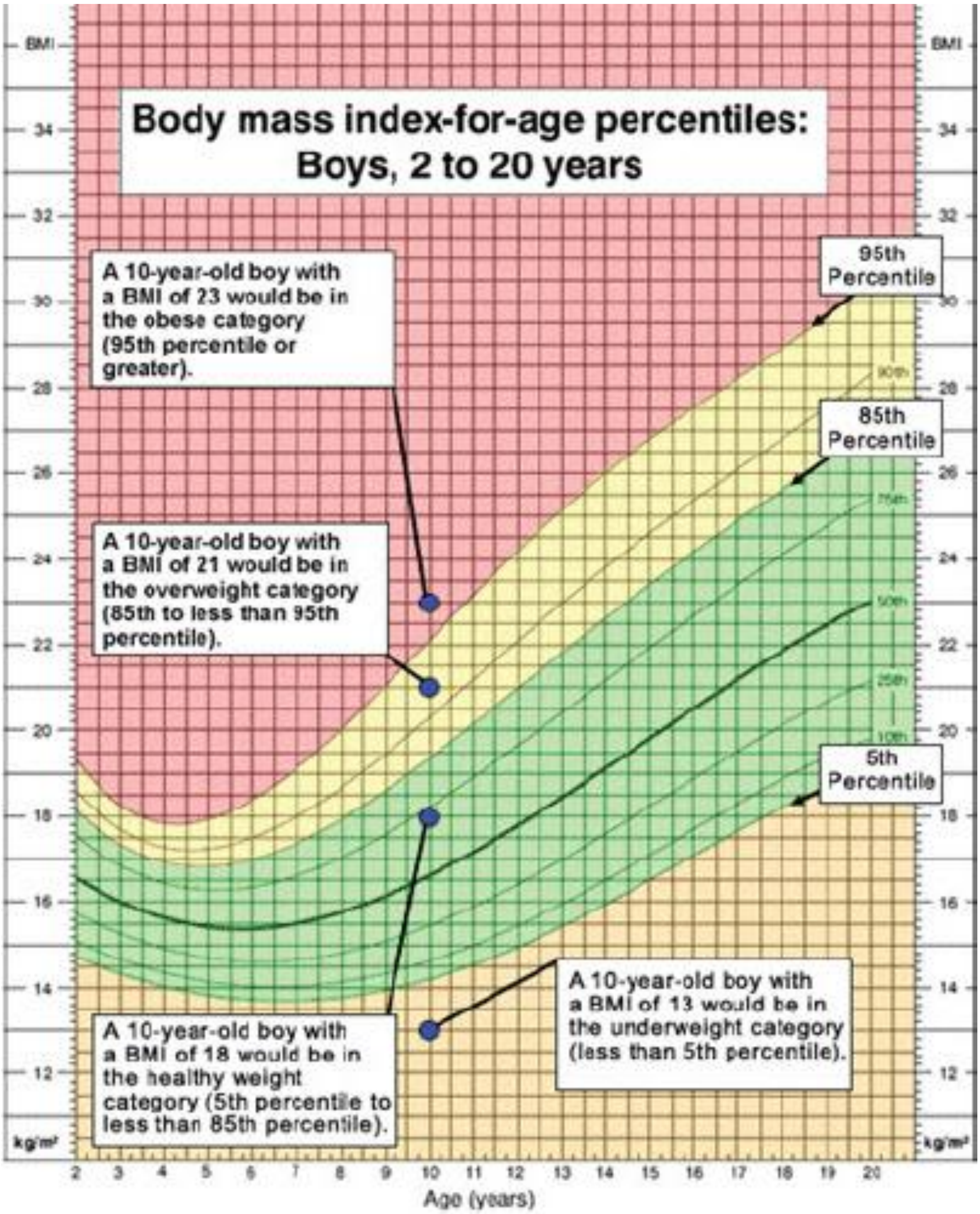
METHOD	PRESENT	ABESENT/REDUCED
Capillary refill	< 2 sec	> 2 sec
Radial pulse		
Ulna pulse		

15.Neurological assessment

NERVE	MOTOR		SENSORY	
Median	Present	Absent	Present	Absent
Radial				
Ulna				

10.3 APPENDIX III





Body mass index-for-age percentiles:
Boys, 2 to 20 years
BMI
34
32
30
28
26
24
22
20
18
16
14
12
kg/m²
A 10-year-old boy with a BMI of 23 would be in the obese category (95th percentile or greater).
A 10-year-old boy with a BMI of 21 would be in the overweight category (85th to less than 95th percentile).
A 10-year-old boy with a BMI of 18 would be in the healthy weight category (5th percentile to less than 85th percentile).
A 10-year-old boy with a BMI of 13 would be in the underweight category (less than 5th percentile).
95th Percentile
85th Percentile
5th Percentile
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Age (years)

10.4 APPENDIX IV

TABLE 4.

Gartland's Classification of Supracondylar Fractures

Type I	Non-displaced.
Type II	Partially displaced with intact posterior cortex.
Type III	Completely displaced with no contact between fractured segments.

Adapted from Gartland[24]