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## Child Deaths

Gürol Canturk, M. Sunay Yavuz and Nergis Canturk  
*Ankara University, Department of Forensic Medicine,*  
*Celal Bayar University, Department of Forensic Medicine,*  
*Ankara University, Institute of Forensic Sciences*  
*Turkey*

### 1. Introduction

Childhood is the development process which starts with birth and continues till adolescence. According to Convention on the Rights of the Child, every individual is a child till the age of 18. A major proportion of childhood mortality is associated with trauma. Natural mortality during childhood is also high. Accidents have an important place with regards to manner of death; however, child homicide is also standing out with its causes and outcomes.

There is a consensus that children less than 10 has lower tendency to commit suicide. The incidence of child suicides increases during adolescence and young adulthood. Deaths during each and every term of childhood possess some unique differences and features. The aim of this section is to assess deaths due to medico-legal reasons during childhood. Childhood mortality may be analyzed under diverse titles according to age groups and manners of death.

### 2. Fetal and perinatal deaths

Fetal death is defined as death before 22 completed weeks of gestation when the conceptus exhibits no sign of life after complete separation from the mother. Perinatal infant deaths include deaths over 28<sup>th</sup> gestational week (late fetal period) and the deaths during postpartum first week. Neonatal deaths occur within 28 days after the delivery; the first week includes early neonatal deaths and the following 2-4 weeks include late neonatal deaths. Neonatal deaths comprise 67% of deaths occurring during the first 1 year of life. The most common causes of death are congenital abnormalities, infections, perinatal asphyxia and metabolic disorders. Perinatal period is of great importance in the perinatal medicine due to higher rate of infant mortality. Natural mortalities, accidents and homicides might occur during this period. Medico-legal investigations are initiated for some perinatal deaths and the cause of death is determined during post-mortem examination. Perinatal deaths include still births, abandoned infants and suspected infanticide (Keeling, 2009a, Pakis & Koc, 2010b, Ozkara et al., 2009).

Childhood mortality globally decreases thanks to socioeconomic development and interventions that keep the child alive. Despite this fact, every year 8.8 million children less than 5 die throughout the world. Infectious diseases (pneumonia 18%, diarrhea 15%, and

malaria 8%) comprise 68% of these deaths. 41% (3.6 million) of these die during the first 4 weeks of life (neonatal deaths). Preterm birth complications, birth asphyxia, sepsis and pneumonia are the most important reasons of neonatal deaths. 49% of deaths among children less than 5 occurred in five countries: India, Nigeria, Democratic Republic of the Congo, Pakistan and China. Birth asphyxia, sepsis, preterm birth complications, and congenital abnormalities are to blame as global totals for neonatal causes of death in these five countries. Most of (83%) neonatal deaths occurred in the African region and in the Southeast Asian region (Black et al. 2010, Lawn et al., 2010).

All relevant information with regards to the event before post-mortem examination should be acquired. There are actions to be taken in cases of concealed pregnancy, unattended delivery and abandonment. Fetal maturity, time of death, was the baby born alive, cause of death and evidence of trauma should be scrutinized. Concealed pregnancy and unattended delivery have higher neonatal mortality risk when compared to in-hospital deliveries. Some findings might be helpful in order to learn whether the baby was born alive or not. Maceration of the baby is a sign of stillbirth. Cutaneous maceration occurs six hours after the death. Deep-red discolouration of the umbilical cord at its fetal insertion is a finding which reveals that fetal death occurred at least six hours before the delivery. Inflammatory change on the umbilical cord is a significant finding. Air in stomach and middle ear, food in the stomach, macroscopic and microscopic findings in the inspection of lungs are assessed in terms of live birth. These questions will be difficult to answer if the body decays. Most of the babies defecate a few minutes after the delivery. Meconium within the colons is also a positive sign indicating full time birth (Keeling, 2009a, Pakis & Koc, 2010b).

Lowest gestational ages and birth weights, congenital malformations and SIDS are the factors playing a role in mortality rates. Moreover, socioeconomic status, ethnicity/race, pregnancy at extreme advanced maternal age ( $\geq 45$  years), obese women, multiple pregnancy, prematurity, diabetic pregnancy, delivering an infant outside the normal working week are reported as risk factors for prenatal, perinatal and neonatal mortality rate (Mathews & MacDorman, 2007, Alexander et al., 2003, Dudenhausen & Maier, 2010, Yogeve et al., 2010, Teramo, 2010, Pasupathy et al., 2010, Flick et al., 2010).

Antenatal and perinatal deaths, premature and intrauterine growth retardation should be taken into consideration as risk factors. Placenta insufficiency is the most important cause of intrauterine growth retardation. Some of the studies report that placenta and umbilical cord pathologies, congenital abnormalities, infections, hyaline membrane disease and trauma at a lower degree are the causes of antenatal and perinatal mortality. Detailed anamneses and post mortem examination are crucial especially for cases in which there is a claim of medical malpractice. Cases with undetermined cause of death are more common among intrauterine and neonatal mortalities when compared to adulthood mortality. This rate reaches up to 50% in some of the studies (Pakis & Koc, 2010b).

A study from Istanbul which includes 184 cases reported that; based on the examinations of lesions and the findings from autopsies, there was no sign to indicate that the neonates were battered with a tool in 96.2% of the cases (Ozkara et al., 2009). Although traumatic cases are rare, it should be remembered that fetal and perinatal mortality might be associated with trauma.

### 3. Sudden infant death syndrome

Sudden infant death syndrome (SIDS) is defined by Beckwith in 1970 as follows: "The sudden death of any infant or young child, which is unexpected by history, and in which a

thorough post-mortem examination fails to demonstrate an adequate cause for death" (Beckwith, 2003). Infant is a term used to describe babies under 1 year of age. All infants who died sudden, unexplained, or unexpectedly (SUDI) are not SIDS. According to a research report, only 39% of SUDI's are SIDS cases (Mitchell et al., 2000). SIDS is one of the major causes of infant deaths between 1 month and 1 year old (Moon et al., 2007). SIDS is a status of not being able to determine the cause of death situation in sudden, unexpected death cases of an infant aged between 1 month and 1 year, although crime scene investigation, family history, microbiological, toxicological and histological studies are made. SIDS is very hard to be diagnosed when it is not possible to reach a diagnosis despite the fact that all the investigations are made in sudden and unexpected infant deaths and in cases of exclusion of other possible diagnoses. Such deaths are natural deaths, the causes of which cannot be determined (Keeling, 2009b).

In sudden, unexpected infant deaths, a detailed history, especially the detailed history of death and crime scene investigation, is the most important part of the research (Willinger et al., 1991). Diagnosis cannot be accessed only by external examination. Bajanowski et al reported unnatural death in 17 of 339 sudden and unexpected death cases which have no evidence at external examination (Bajanowski et al., 2005). In the Istanbul study carried out in all children mortality cases under the age of 18, deaths between the ages of 1 month and 1 year were reported as 21.9% (Canturk et al., 2007).

Although pathogenesis is not clear, the number of SIDS reduced in recent years (Van Norstrand & Ackerman, 2010). Possible mechanism is re-breathing carbon dioxide by infants who are thought to have been stayed in a small unventilated area (Patel et al., 2003). (Figure 1). Epidemiological studies trying to identify genes and genetic factors are associated with SIDS. Central nervous system pathways, cardiac channalopathies, immune dysfunction, differences in response to nicotine metabolism and energy pathways are investigated (Van Norstrand & Ackerman, 2010).



Fig. 1. Infant is re-breathing carbon dioxide.

Prone and side sleeping position, soft bed and sleeping pad, beret, and bonnet use during sleep, bed sharing and too hot sleep environment are risk factors (Kinney & Thacch, 2009). Similarly, being male infant, preterm delivery, high risk pregnancy, twin pregnancy, being multi-parity mother's baby, living within large family are other risk factors. Single and young mothers, mothers who smoked during pregnancy, and who give birth to children with low birth weight are risky. Low socio-economic level is known to be risky (Daltveit et al., 1997, Blair et al., 2006). And it is reported that low socio-economic level also causes other risk factors (Fleming et al., 2003). In a study it is reported that SIDS babies are sharing beds in 70% cases (Brixney et al., 2011). In SIDS cases, most infants die while sleeping in their bedrooms. Death usually occurs in the morning while asleep. (Fleming et al., 2003). Babies are usually 2-4 months old, and usually not followed-up in the prenatal period. Low parental education level, short time drug usage of mothers during pregnancy and winter months are also risky (Byard & Krous, 2003). Bottle feeding and avoiding breast feeding are risk factors, too (Blackwell et al., 2005). Inflammatory changes are often in SIDS cases and infection is a moderate risk factor (Highet, 2008). Staphylococcus aureus, Streptococci and Escherichia coli have been reported to be related pathogens (Blackwell et al., 2005). Also, smoking at home is a risk factor and is associated with the number of cigarettes (Blair et al., 1996). An apparent life-threatening event (ALTE) is a state of emergency, characterized by central or obstructive apnea, skin color change (pallor or cyanosis), decreased muscle tone (hypotonia) and a combination of choking or gagging (National Institutes of Health Consensus Developmental Conference on Infantile Apnea and home monitoring, 1987). ALTE identified in the siblings is thought to be caused by obstruction of the upper airway (Southall et al., 1997). Even if a single episode of unexplained ALTE exists in the anamnesis, SIDS should be suspected (Romanelli et al., 2010, Rosen et al., 1986). Alcohol consumption within family and sleeping together has been reported to be risky in previous studies (Phillips et al., 2011).

History is very important in cases of SIDS. Most of the time before the scene investigation, there may have been an intervention in the scene. The previous death of a baby, who belongs to the same family, the history of pregnancy and the baby's medical history up until death are important. The presence of a dead sibling may cause the investigator to suspect about the possibility of hereditary disease and death as a result of abuse (Meadow, 1999).

In unexpected infant mortality, sleeping environment should be examined carefully in terms of asphyxia and extreme heat (Figure 2). The exact position of the baby, the proximity degree of the bodies during sleep with mother and father, blankets, pillows, quilts and blankets should be investigated as to whether appropriate for use or not. Alcohol and substance abuse in the family, level of parents' fatigue should be questioned (Keeling, 2009b). SIDS, which cannot be diagnosed without detailed main aims in autopsy, differentiates natural and unnatural death, and determines the cause of death (Ozkara et al., 2009). Radiological, microbiological and pathological studies including toxicology and neuropathology contribute to the autopsy. For toxicological examination, blood, urine, and intraocular fluid, if the eyes cannot be examined pathologically, should be sampled (Keeling, 2009b). Genetic analysis should be done in the SIDS cases. (Klaver et al., 2011). When diagnosed ones are subtracted from the SUDI cases, cases with specific criteria for SIDS should be classified as SIDS and others should be classified as deaths of unspecified cause. (Cologlu & Cakalir, 1999). Multidisciplinary, detailed and meticulous research is very important in sudden unexpected child deaths (Inanici et al., 2001).



Fig. 2. Broken bed should not be used.

In evaluation of outward appearance, well-groomed infant child can have minor malformations or dysmorphic features. Frothy secretions in nose holes are common. Occurrence of dead marks on the front of the face and chest indicates the prone position of the baby. Hyperemia of internal organs and non-specific changes are seen in asphyxia (Cologlu & Cakalir, 1999). Thymus should be examined carefully. Generally, size of the thymus is found in normal range. A large number of thymic petechiae which is the most important and most common manifestation of SIDS is found especially in the thoracic region and mostly seen on the posterior face (Keeling, 2009b). Small and numerous petechiae also can be found on subpleura (Goldwater, 2008). On epicard and pleural face of diaphragm, petechiae can exist (Cologlu & Cakalir, 1999). Petechiae attend to more than 80% of Beckwith's cases (Beckwith, 1988). 61% of SIDS cases in Kleemann's study had petechiae (Kleemann et al., 1995). At this age, mesenteric lymph nodes are often expanded as a reflex to the level of environmental antigenic stimulation (Keeling, 2009b).

The origin of sudden infant death can be natural illness or trauma. This can also be valid for adults (Pakis & Koc, 2010a). Infection is one of the major causes of death in this age group and should be considered in the differential diagnosis (Canturk & Canturk, 2001). In this case, microorganisms can be detected by molecular methods (Baasner et al., 2003). Cardiovascular system-based deaths are common. Cardiomegaly should be warning for researchers about cardiovascular origin. Cardiac malformations, ventricular septal defect (Cohle et al., 1999), coronary artery anomalies should be investigated (Rowley & Shulman, 2010, Lipsett et al., 1994). Although rare, myocardial infarction in the neonatal period is defined (Canturk et al., 2006), severe cardiomyopathy can also be seen (Dettmeyer & Kandolf, 2010). It is important to diagnose these cases, because many of them are familial (Pakis & Koc, 2010a). Dysrhythmias are varied, but complete bundle branch block is common. This diagnosis is important in terms of pregnancies of infant's mothers and close

relatives. Postmortem genetic analysis shows that cardiac ion channel mutations like Brugada syndrome, long QT syndrome and short QT syndrome are associated with SIDS (Goldwater, 2008). Other possibilities are genetic-metabolic diseases, and the beta-oxidation defects are considered in this group. Presence of hypoglycemia and hyperammonemia which are common in these diseases can trigger infections (Keeling, 2009b). Sudden unexpected death in epileptic children can be seen (Sillanpää & Shinnar, 2010).

Definitive histological evaluation is important in SUDI cases. Pulmonary edema and congestion are common findings in SUDI cases. Round-cell infiltration is often located on alveolar wall and there are peribronchial lymphoid aggregates (Keeling, 2009b). In 60% of SIDS, focal acute inflammation exists in the upper and lower respiratory tract (Krous et al., 2003). In many SIDS cases, arcuate nucleus hypoplasia, periventricular leukomalacia and brain nucleus subtle gliosis can be found (Keeling, 2009b). Relatively, gliosis in the brain is a common finding (Kinney, 2005). Also continuing hematopoiesis in the liver is one of the findings of SIDS and found to be significantly higher, compared with the control group (Töro et al., 2007).

#### 4. Natural deaths in infants and children

Sudden natural deaths in childhood constitute about 5% of all deaths (Aleszewicz-Baranowska, 2002). Causes of natural death in infants and children relevant with all systems, especially related to the cardiovascular system (Variend, 2009). The most common and mortal cause of childhood cardiovascular system diseases are myocarditis, hypertrophic cardiomyopathy, long QT syndrome and Preexcitation syndromes with aortic stenosis, tetralogy of Fallot, transposition of great arteries, Ebstein's syndrome, congenital heart defects, such as coronary artery anomalies (Aleszewicz-Baranowska, 2002, Vetter, 1985). The adolescent period, cardiomyopathies are reported as the most common cause of sudden cardiac death (Thiene et al., 1988).

Causes of natural death in children and infants vary from country to country and due to living in urban or rural areas and age. While in developed countries, congenital anomalies, premature birth, birth trauma, malignancies are the causes of death, in developing countries, preventable causes like infectious diseases, nutritional disorders, etc. are seen primarily. Diseases-related deaths are seen more often in urban than rural areas. While, children between the ages 1-4 infections are main cause, cardiovascular causes, epilepsy, intracranial hemorrhage, and asthma are prevalent in children elder than 14 (Neuspiel & Kuller 1985). In developing countries, sepsis and other infections are among the leading causes of deaths under the age of five. Neonatal tetanus, malaria, measles in Nigeria, congenital syphilis, measles, AIDS in Papua New Guinea and tetanus in India has an important role among the causes of death (Bamgboye & Familusi, 1990, Aikhionbare et al., 1989, Duke et al., 2002, Choudhury et al., 1991). In Tokdemir et al's study; under the age of 18, 178 case of whom autopsies evaluated in Elazığ between 2001-2007, in 7.8% of them death cause were resulted as natural , 92.8% of cases were determined in the 0-5 age group, and the cardiovascular system took the second place, after the respiratory system diseases (Tokdemir et al., 2009).

Mortality rates under 5 years old also vary from country to country. According to 2009, World development indicators of the World Bank, Mortality rates under 5 years old is 7,8 in USA, , 4.2 in Germany, 3.20 in Turkey and 198.6 (for 1000 new-born baby) in Afghanistan (World Bank, World Development Indicators).

## 5. Asphyxial deaths

Death from asphyxia is common among childhood deaths. Except drowning, entrapment asphyxia, foreign body inhalation, plastic bag asphyxia overlaying and wedging, strangulation, hanging by a ligature, imposed airways obstruction, abuse of inhalants, chemical asphyxia can be considered among the causes of deaths from asphyxia (Byard, 2000, Busuttil, 2009b).

According to ICD asphyxia is defined as follows:

- - Accidental drowning and near drowning
- - Obstruction of the airways due to inhalation or any foodstuff or suffocation
- - Obstruction of the airways due to inhalation or any foreign body or suffocation
- - Accidental mechanical suffocation.

Petechiae is still accepted as the pathognomonic finding of asphyxia. It is not rare to see such haemorrhage in a single zone or only in the eyes. It can be seen on the anterior chest wall and on the body as well in early neonatal deaths and stillbirths due to retroplacental haemorrhage (Busuttil, 2009b).

### 5.1 Entrapment asphyxia

The curiosity of children related to various objects and spaces can result in difficult situations and they cannot escape from such difficulties and might die. Box type freezers, refrigerators, old cabinets, large chests, suitcases that are left idle within children's reach may lead to problems. To be locked in the trunk of a car can have a similar effect.

There is an accidental asphyxia case reported in the literature, in which the person's head got entrapped in the car window (Byard & James, 2001). In the USA between the years 1987-1998 11 pediatric cases were reported. The children reported were at the age of 6 or younger and kept locked in the trunk of automobiles and died due to hyperthermia and asphyxia (Centers for Disease Control and Prevention, 1998). A study conducted in Australia indicated that 13 (31%) out of 47 non-intentional asphyxiation cases were due to head and neck entrapment (Altmann & Nolan 1995). It was also reported that a 19 month old girl died due to the neck compression since her neck got entrapped in the shopping cart (Jensen et al., 2008).

When a child is kept closed in the car in a hot day, heat stroke may develop due to the asphyxial changes together with the heat effect. If the ambient temperature is more than 29.5° C, such deaths may happen. If the ambient temperature is more than 29.5° C, the temperature in the vehicle will be more than 55 ° C (Busuttil, 2009b).

### 5.2 Plastic bag asphyxia

As plastic bags are common in our daily life, children play games with plastic bags. They put plastic bags over their heads and may die accidentally while they are playing with plastic bags. Such deaths are not rare. Moreover such deaths are common among the children who are solvent abusers (Saint-Martin et al., 2009).

In many countries it is legally obligatory to make holes on plastic bags that will enable air flow (Busuttil, 2009b).

### 5.3 Hanging by a ligature

Hanging by a ligature is not common among the children under the age of 14. The studies in the literature are mainly case reports and epidemiological studies are missing. It is more common among boys. Cervical spine, hyoid, or thyroid fractures are not frequently seen.



In the USA hanging/suffocation rate among the individuals between the ages 10 and 24 was increased significantly from 1992 to 2006 (Jones et al., 2000). In Australia there is also an increase in hanging by both males and females between the years 1998 and 2007, when compared with the previous decade (Bridge et al., 2010).

In the background there is misery or depression. Post-mortem psychological evaluation shows failure at school and pretension behaviors among the peers. These children might try to hurt themselves before. Autoerotic accidental deaths are reported among children at the age of 9 and above (Busuttil, 2009b, Large & Nielsens 2010).

#### **5.4 Traumatic asphyxia**

Traumatic asphyxia is rare in children. It is generally associated with crush injuries. The pathophysiology is different from adults (Large & Nielsens 2010). In the literature there are some case reports concerning crush under car or jeep tires, or under some objects or garage door (Wyatt et al., 1998, Nishiyama & Hanaoka 2000). When thorax is stable, but there is no respiratory movement, traumatic asphyxia can occur. Central cyanosis and petechial hemorrhage are classical with congestion findings end up at the level of clavicles at the superior part of the obstruction. In children such findings are observed at the superior part of the obstruction, in case the children are crushed in the crowd or under the walls or any other object due to explosion, conflicts, or natural disasters such as earthquakes and oil explosions.

Another type of accidental asphyxia is related to traffic accidents, in which the child is crushed under the vehicle. Mostly internal organ damage and diffuse soft tissue injuries are seen in children. The abrasions frequently seen on the body of the child show the direction of the car passing over the child in line with the dragging direction. The majority of these children are under the age of 3 and they are male (Busuttil, 2009b).

#### **5.5 Foreign body inhalation**

Aspiration of foreign bodies can be fatal particularly in the first year of life. Anatomical and physiological characteristics and behavioral factors cause higher risk in terms of foreign body aspiration among the children under the age of 3 (Hurtado & Della-Giustina 2003).

Frequently toys or foodstuff cause foreign body aspiration in children. Although the majority of these cases show immediate symptoms while the child is eating, there are also some cases that result in the death of the child in the sleep without showing any immediate symptom. Foreign body caused for the death can be identified in the airways during the autopsy.

Aspirated solid or semi-solid foreign body may set in the main bronchi, trachea or larynx of the child. If the foreign body is large enough to close the air way totally, then there will be an immediate asphyxia due to lack of air through the lungs (Busuttil, 2009b).

There is more risk in laryngeal spasm and death due to laryngeal foreign body, when compared to foreign bodies in the trachea and bronchi (Hurtado & Della-Giustina 2003).

It is reported that the foreign bodies mostly go to the right bronchus due to the anatomical position (Hurtado & Della-Giustina 2003).

The inhaled vegetable particles might swell up in the forthcoming hours and even days and cause cough, stridor, wheeziness, short of breath and cyanosis. Peanut and other organic foreign bodies aggravate asphyxia through tissue edema due to acute inflammatory response. The American children between the ages 1 and 3 are under a higher risk. It results in 0.7 deaths per 100,000 annually. Death from foreign body inhalation is due to the

tendency of children to put everything into their mouths. Such young children do not have molar teeth. They tend to chew foodstuff with their incisors. When any foodstuff is sent back they are inclined to inhale due to a reflex reaction (Busuttil, 2009b).

Toddlers possess higher risk in terms of foreign body aspiration. If there is any mastication problem or dysphagia in older children, food aspiration might be seen. The fatality risk is more in mentally retarded children or in children suffering from neurological disorders such as cerebral palsy. On the labels of the packaged foodstuff the appropriate consumer group should be stated for the safe consumption of the foodstuff (Byard, 2000).

### **5.6 Overlaying and wedging**

The baby is overlaid by an adult during the deep sleep phase or the baby is accidentally suffocated due to sleep induced extraneous intoxication. The risk of overlaying is the highest in the babies under the age of 5-months. However overlaying can be seen in children until the age of 2. An adult or an older child who is overlaid the child, cause him/her to be kept under the bed or pillow. The child cannot cry due to the pressure in his/her chest and cannot take attention. In some of these babies expected clinical findings and even petechia cannot be seen. In some cases, unusual lividity indicating the pressure zone can be observed besides contusions and abrasions (Busuttil, 2009b).

For many years accidental suffocation cases of infants are considered as the cause of SIDS when infants sleep with their parents. Recently it is being debated that overlaying is a cause of SIDS. The reason for the debate is that the autopsy findings, crime scene investigation, family history and epidemiological findings are not different in SIDS and overlaying (Byard, 2000).

Kirchner reported 515 mortality cases under the age of 2 in a period of 7 years. 121 out of 515 cases died due to overlaying by their parents, siblings or other adults. Kirchner also reported that 77% of these cases were under the age 3-months. 394 out of 515 deaths happened due to entrapment in the bed. 296 of them died in the beds of their parents. According to Kirchner's report 79 cases died in the waterbeds. 2 cases died due to alcohol and substance use. 10 cases died in the adult sunbeds and finally 9 cases died in adult beds with rails (Busuttil, 2009b).

### **5.7 Strangulation**

Although strangulation is a homicide and suicide-related cause of death in adults, it is an accident-related cause of death due to asphyxia in children. It is the 4<sup>th</sup> most common cause of unintentional injuries for infants under the age of 1 after traffic accidents, drowning and burns (Chinski et al., 2010).

Unintentional or accidental self-strangulation is quite commonly reported in young children mostly by use of a loose wire, rope and other potential ties typically around the house and frequently close to the bed. Tangled death cases account for 14,3% of all childhood mortality in the US. (Busuttil, 2009b).

### **5.8 Airway obstruction**

One way of child abuse is to cover infant's mouth by soft materials such as pillows and to press the infant against the chest by parents or other care givers. The infant may not seem to have tried hard but there might be signs of convulsions due to cerebral hypoxia following hypoxia and cyanosis without the presence of significant traumatic findings; respiratory and

cardiac arrest may follow. This situation may be caused by a mother previously diagnosed with Munchausen by Proxy willing to draw attention due to her psychosocial problems. External examination may not indicate any finding, but presence of haemosiderin deposition in lungs both in alveolar cells and interalveolar septa is a quite critical finding. (Busuttil, 2009b).

### **5.9 Solvent abuse**

Inhalable hydrocarbons generally create an impairing effect on mental functions similar to alcohol or substance abuse. They contain petroleum and petroleum products that are present in the composition of many household products such as cleaning and decorating materials, paints, polishers, lacquers, adhesives, room sprays, hair straighteners, dry cleaning solvents, shoe polishes, labels or stain removers. Death may happen in various ways. Reports indicate use of such substances by older children for arousal during autoerotic activity.

Autopsy may reveal limited information in such suspected abuse cases. The body may present rashes and vesicles around the mouth orifice due to the effect caused by the solvent on the skin. Solvent may be olfactive during post-mortem examination. One of the lungs should be taken inside a plastic bag for analysis. Blood, liver and kidneys may also be examined toxicologically (Busuttil, 2009b).

### **5.10 Reverse suspension**

This rare condition presents a situation, where the organs of a child changes position in the upward direction during a game activity resulting in shifting of the diaphragm and air depletion ultimately causing death. Death happens slowly when respiratory efforts are consumed (Busuttil, 2009b, Kurtzman et al., 2001).

### **5.11 Chemical asphyxia**

This is a term used in the presence of non-inhalable gases around the child. For instance, kerosene and paraffin as a fuel, carbon monoxide liberated from fires or from exhaust smoke or barbecue coal in closed spaces or chlorine effusing from swimming pools, hydrogen sulphide and methane emitting from outdated mines and gases dispersing from catch basins may cause mortality. These conditions generally affect elderly individuals, mobile kids and mostly boys in environmental accidents. (Busuttil, 2009b, Meyer et al., 2007).

## **6. Drowning**

Drowning happens due to aspiration of water into upper and lower airways by the reflex at the end of the apnea time (Yorulmaz & Cakalir, 1999). Drowning is the second most common cause of traumatic death for children between the ages of 1-14 (Gilchrist et al., 2004, Bener et al., 2011). In most of the drowning cases, death happens due to hypoxemia and subsequent cerebral hypoxia following inhalation of water down to alveoli (Gok, 1983a). 40% of all drowning cases involve children (Canturk et al., 2009). A study conducted in Istanbul on child mortality reports drowning as the cause of death in 79 out of 736 children (10.73%) (Canturk et al., 2007). Drowning may happen in the bathroom, toilet, buckets and jerry cans, swimming pools, ponds, decorative pools, building sewerage

systems, farming reservoirs and tanks, canals, lakes, streams, creeks and sea (Pearn, 2009). The origin of childhood drowning is generally accidental (Brüning et al. 2010). Children between the ages of 1-4 represent the high-risk age group (Iqbal et al., 2007). Summer months are quite risky for drowning events since the weather tends to be warmer than the rest of the year (Canturk et al., 2009). Male gender, African race and adolescent age are the other risk factors (Bener et al., 2011, Hyder et al., 2008). Drowning cases are mostly reported in weekends and between 14.00-19.00 hours (Tyebally & Ang, 2010).

All dead bodies taken out of water should not necessarily be considered to have died of drowning and the person might have died because of

1. A natural disease before he/she has fallen into the water,
2. A natural disease when he/she was in the water,
3. Trauma before having been thrown into the water,
4. Traumatic reasons when in water,
5. Hypothermia and sympathetic inhibition, parasympathetic stimulation in cold water,
6. Drowning (Yorulmaz & Cakalir, 1999, Knight, 1996d).

Every drowning is a forensic case. One should always remember that child abuse or non-accidental injury, homicide, euthanasia and negligence may go along with the anatomical – pathologic characteristics of drowning. A detailed crime scene investigation and witness statement taking process should continue with a thorough anamnesis taking and post-mortem examination, if necessary to be complemented with radiography, chemical examination, diatomeae analysis and photograph taking (Canturk et al., 2009). Drowning does not have any specific laboratory finding to help with the diagnosis and therefore it is one of the most challenging diagnostic works of forensic pathology (Arslan et al., 2005). Since there is no specific histopathological finding to diagnose drowning, other possible causes of death should be ruled out by way of autopsy, histopathological examination, chemical and toxicologic examination. Lung alterations are not specific in drowning cases (Yorulmaz & Cakalir, 1999, Knight, 1991). Diagnosis is even harder in pediatric cases. Since the time of staying in water is only minutes in 99% of pediatric cases, the amount of ingested water may be very small, which challenges the diagnosis (Pearn, 2009).

Mortality due to cardiac arrest that develops by laryngospasm or vasovagal mechanism in absence of fluid in airways is defined as dry drowning (Yorulmaz & Cakalir, 1999). The macroscopic appearance of lungs may differ depending on fresh or salty nature of the drowning water. Since the salty water coming into the alveoli is hypertonic, the water in the vascular bed passes onto the alveoli causing hemoconcentration in blood, hypovolemia and severe pulmonary edema presenting with bloody-fluidy wet appearance in lung cross sections. Drowning in fresh water, on the other hand, presents with hypotonic water coming in the alveoli passing the water from vascular system to the blood and consequently causing hemodilution, hypervolemia and hemolysis creating a drier look in the cross sections of the lung than in drownings in salty water (Demirci & Dogan, 2010). There are age-related risk factors for drowning of children. The most common drowning spot for children is the swimming pools. Buckets, washbowls and Jacuzzis also constitute risky zones for children aged 4 and under. (Tyebally & Ang, 2010). Toddlers may drown when left unattended in the bathtub or when left alone with full buckets, whereas adolescents mostly drown outdoors, in which case possible alcohol intake may be the case (Byard, 2000).

Drowning zones mostly depend on communities and geographical position of their water resources (Byard, 2008, Wang et al., 2010). Nevertheless, the most common drowning zone for childhood events is the swimming pools. (Tyebally & Ang, 2010). In as much as

swimming is the fun and healthy way of refreshing in summer months, it brings along the risk of drowning (Schwebel et al., 2007). Most of the drowning cases in swimming pools and sea involve victims in the age group of 5-15. Boys tend to drown more than girls in swimming pools and sea (Tyebally & Ang, 2010, Pelletier & Gilchrist 2011).

80-90% of child drownings in bathtub are accidental. Particularly, infants under 12 months are under risk (Somers et al., 2006). Drowning cases have been reported by use of bathtub seats and rings when bathing infants in bathtubs (Rauchschwalbe et al., 1997). Inefficient adult attendance and bathing of more than one infant constitute risk factors (Somers et al., 2006). As a classical story, the tired mom starts bathing her children during which the telephone rings or the door knocks causing a sudden and unexpected interruption of the family routine. The mom lets her children stay in the bathtub, when older children get out of the bathtub leaving the younger child alone. The victim is generally the youngest or the second youngest child of the family (Pearn, 2009). Although drownings in buckets or washbowls are generally accidental, the possibility of homicide should not be overlooked in these cases (Pearn, 1992). Most of the victims are younger than 12 months with an age interval of 7-15 months. (Mann et al., 1992)

Children may also drown in rivers, lakes, creeks, sewerage systems and trenches. 90% of cases are boys mostly in the age group of 8-12. They generally drown when playing or swimming in prohibited areas, in which case their friends can't help or more than one child may die (Pearn, 2009).

Presence of fungal foam in external examination would be the strongest finding to indicate drowning in water. Localization of post-mortem stains is consistent with the body position. Goose skin look, wet skin, launderer's hand and foot are the findings that can manifest themselves only in long time stay in water. In drowning cases that present with both non-specific asphyxia symptoms during internal examination (hyperemia, Tardieu's spots, edema and hyperemia in internal organs) and fluid aspiration, lungs are hyperemic, bright and swollen. Furthermore, materials belonging to the drowning site such as algae or sand may be present in the respiratory system. Post-mortem radiologic examination should also be performed to rule out the possibility of child abuse. Besides, alcohol and drug analysis should also be performed as a part of toxicologic workup. Toxicologic workup may reveal content of the drowning fluid from the lung tissue. Although false positive or negative results should be reassessed, diatom analysis from bone marrow is especially important for drowning in the sea. (Yorulmaz & Cakalir, 1999, Canturk et al., 2009, Pearn, 2009, Knight, 1996d, Demirci & Dogan, 2010, Geserick et al. 2010).

## 7. Poisoning

In parallel with technological developments, there has been an increase in the risk of poisoning due to the increase in the number of chemical substances and drugs. Poisonings are important causes of pediatric emergency service applications and of morbidity and mortality in children and adolescents (Andiran & Sarikayalar 2004, Cheraghali & Taymori 2006).

Reasons for intoxication show variability in a wide range. Among these; drugs, various chemicals, pesticides, solvents, toxic gases or smokes, a variety of metals and minerals, animal bites or stings, and some poisonous plants and foods can be counted (Gurpinar & Asirdizer 2006). Epidemiological features of childhood poisonings differ from country to

country and vary depending on socio-economic and cultural conditions of communities (Senanayake & Karalliedde 1998, Paritsis et al. 1994).

Based on data from United States of America Poison Control Center, it is indicated that approximately two and a half million poisonings occurred in 2008, 38,7 percent of which were under 3 years of age and more than half of which were under six years of age (Bronstein et al., 2008).

The pattern and risks of intoxication vary depending on age (Marchi et al., 1991, Soyucen et al., 2006). Poisonings in children under one year old include therapeutic errors such as false drug dose adjustment of doctors or families, or prescribing mistakes, while in children between the ages of 1-5 accidental poisonings and over the age of 10, suicidal poisonings are common (Andiran & Sarikayalar 2004).

Food poisoning, which occurs as accidental ingestion of toxic substances, is one of the most important causes of poisoning in children and is most frequently seen among boys between the ages of 1-5 (Marcdante, 2006, Mert & Bilgin 2006, Dart et al., 2007, Busuttil, 2009a, Hoffman & Osterhoudt 2002). Since children can be curious and tend to bring everything in their mouths without noticing that they can be harmful, food poisonings are common in these ages (Roidgers & Matyunas 2002). Intentional (voluntary) poisoning is another cause of poisoning seen in children and is more common among adolescent girls (Soyucen et al., 2006, Marcdante, 2006, Dart et al., 2007, Busuttil, 2009a, Bana, 1997). Compared to adolescents, children are more sensitive to environmental stresses and their emotional reactions are higher due to hormonal changes, and suicide attempts are seen more commonly.

Substances causing intoxication differ from country to country. It is reported that poisonings mostly occur as a result of oral intake of substances and drugs are the most common causing agents of acute toxicity (Andiran & Sarikayalar 2004, Marchi et al., 1991, Soyucen et al., 2006, Dart et al., 2007, Yavuz & Ozguner 2003, Ucar et al., 1993). In Western Europe and North America, domestic products, drugs, carbon monoxide and volatile substances take the first place, while in developing countries, causes such as pesticides, household products, medicines, animal or insect bites are in the forefront (Ellenhorn, 1997, Cardozo & Mugerwa 1972, Jamil, 1990).

The majority of childhood poisonings occur at home and approximately 45% of home accidents are acute poisonings (Asirdizer et al., 2005). It is notified that, in Andiran et al's study performed in Ankara, 93.3% third of poisoning cases occurred at home (Andiran & Sarikayalar 2004); in Petridou et al's study realized in Athens, 88.7% of scene was home and living room, bedroom or kitchen (Paritsis et al. 1994); in Soyucen et al's study performed in Sakarya, 92.7% of poisonings occurred in the house (Marchi et al., 1991). According to the World Health Organization, toxicity-related death rates in children between the ages of 1-14 are 0.05 in Denmark, the 0.12 in USA and Canada, 0.75 in Korea (Busuttil, 2009a).

## 8. Road traffic accidents

Death due to road traffic accidents is one of the major reasons of childhood mortality (Durkin et al., 1999). The global economic cost of motorized vehicle accidents and injuries of pedestrians is around USD 500 billion.

WHO reports that injuries due to road traffic accidents is still an important public health problem. 1.2 million people die and 50 million people are injured due to traffic accidents in the world annually (Chakravarty et al., 2007). In 27 Member States of the EU around 50000

people, 8500 of whom are pedestrians, die due to traffic accidents (Arrequi-Dalmases et al., 2010).

Road traffic accident issue is a major public health problem for particularly low and medium income countries. Contrary to the low and medium income countries, pedestrians constitute the largest group in the traffic accident related injuries and mortalities in the high income countries (Mabunda et al., 2008). It is reported that low socio-economic status is an increasing risk factor for child pedestrian deaths, and that the children with low socio-economic status has 4-5 folds more mortality risk when compared the children with the highest socio-economic status (Desapriya et al., 2011, Busuttill, 2009d).

In accordance with the National Highway Traffic Safety Administration (NHTSA) report 4641 pedestrians died in 2004 in USA. This number corresponds to 11% of the traffic accident related deaths. Pedestrians generally make fatal mistakes in the afternoon or evening time when crossing a street. Pedestrians at the age of 12 and below are found faulty in the accidents in 90% (Ulfarsson et al., 2010).

The number of in-vehicle deaths in traffic accidents particularly in the developed countries has a decreasing trend in recent years. The ratio of mortality between the ages 0 and 14 due to traffic accidents in Europe is 48 %. The ratio of pedestrians between the ages of 15 and 17 died in traffic accidents is 21 %. Although the pedestrian mortality is high in the less developed countries, this problem is not rare in the developed countries. For instance the number of pedestrian deaths in the USA was 4675 in 2004 and increased up to 4881 in 2005. Recently around 5000 pedestrians die and 600000 pedestrians are injured in the USA annually (Chakravarty et al., 2007, Arrequi-Dalmases et al., 2010). The ratio of pedestrian deaths to the traffic accident related deaths in Hong Kong is more than 50%. This ratio is higher than the ratio in the USA, Japan and many western countries. Children possess high injury and mortality risk in traffic accidents. The risk is highly correlated with driver characteristics, socio-economic environment and demographic characteristics of victims (Sze & Wong 2007). The following factors have a serious impact on the injuries in road traffic accidents: type of the vehicle, speed of the vehicle, size of the vehicle, impact angle of the vehicle, center of gravity of the pedestrian when the vehicle comes into contact with the body of the pedestrian, driver characteristics and alcohol intake (Chakravarty et al., 2007).

The researchers focus on the socio-economic characteristics of children, particularly the pedestrians, undergone traffic accidents. Types of injury depend on the age, gender and socio-economic status of the individual. The risk of death for child pedestrians is found associated with the socio-economic status, economic conditions of the family and ethnicity (Chakravarty et al., 2007, Mabunda et al., 2008, Busuttill, 2009d, Graham et al., 2005, Newbury et al., 2008, Presley et al., 2007).

Pedestrian injuries and deaths have an increasing trend in the world. Children constitute the most sensitive group among the pedestrians in traffic accident related injuries and deaths. Pedestrian injuries are the second most common cause of death among the involuntary injuries between the ages of 5 and 14. Children below the age of 15 have a ratio of 8% in overall pedestrian deaths due to road traffic accidents in the USA. On the other hand this age group comprises 30% of the overall pedestrian injuries (Chakravarty et al., 2007). In-vehicle injuries due to road traffic accidents are mostly seen at the age group of 10-19. Injuries related to bicycle accidents are mostly seen at the age group of 10-14, and the injuries related to motorbike accidents are commonly seen at the age group of 15-19 (Agran et al., 2001). In Africa the traffic accident related pedestrian deaths constitute the most significant group. In four provinces of South Africa 7433 pedestrian deaths were reported

between the years 2001 and 2004. 18.8% of the deaths in question were children and adolescents under the age of 20 (Mabunda et al., 2008).

It is reported that children in adverse circumstances are inclined to traffic accidents. It is thought that environmental characteristics play a role in traffic accidents (Durkin et al., 1999). It is stated that around 85% of the deaths due to traffic accidents happen in medium and low income countries (Hyder et al., 2006).

The majority of the injuries due to road traffic accidents happen generally in the afternoon or evening time or on weekends. According to some studies deaths mostly happen in summer. The majority of deaths are seen between 6 p.m and 12.00 p.m. as per the American national data. When it gets dark, the sight distance of drivers may be shortened. Together with alcohol intake and pedestrian traffic, it might affect the occurrence of traffic accidents. It is reported that mostly boys get injured and die due to traffic accidents (Durkin et al., 1999, Chakravarty et al., 2007, Mabunda et al., 2008, Desapriya et al., 2011, Newbury et al., 2008).

Different studies are concluded with different results concerning the scene of traffic accidents - whether in the city center, suburban or rural areas - that resulted in injury or death of children. Some studies indicate that road traffic accidents mostly happen in the city center, whereas some others state that road traffic accidents are mainly seen in rural areas (Chakravarty et al., 2007, Mabunda et al., 2008, Desapriya et al., 2011). However it is generally asserted that accidents happen at the vicinity of the child's home (Busuttill, 2009d). Alcohol plays an evident role in motorized vehicle accidents likewise in pedestrian injuries. Alcohol intake is common among the drivers and the pedestrians. In 2005 the number of the pedestrians died in alcohol related traffic accidents in USA was 2180. This number comprises around 45% of the overall pedestrian deaths. The pedestrian or the driver might take alcohol (Chakravarty et al., 2007). In accordance with the study conducted on road traffic accidents in four provinces of South Africa, alcohol intake was confirmed in 58% (2326) of the cases tested for alcohol (Mabunda et al., 2008).

The children's body parts injured due to traffic accidents were studied in various studies. Head trauma is the most common injury. The ratio of head trauma differs on the basis of the fact whether the child is a pedestrian, or in the vehicle, or riding bicycle (45.4% among pedestrians, 40.2% among riders, 38.9% in vehicle). Besides head trauma, spinal, thorax and abdominopelvic traumas also result in severe injuries and deaths (Durkin et al., 1999, Arrequi-Dalmases et al., 2010).

According to a study conducted in Manhattan, USA, the number of injuries among the school age children per 100.000 persons is 127.2 for pedestrians, 37.4 per riders and 25.5 for children in the vehicle. The number of the children having accident - whether pedestrian (6-10 ages) or rider (9-15 ages) - peaks in summer and in the afternoon time. The number of the children having accident in vehicle (12-16 ages) shows little variation on the basis of seasons and tends to increase in the evening and night hours. Traffic accidents peak at the age of 15. 22.1% of the severe injuries of the school children between the ages 5 and 16 are related to traffic. Around 2/3 of the individuals severely injured and 3/4 of the individuals died in the road traffic accidents are the pedestrians (Durkin et al., 1999).

Riding bicycle is a popular childhood activity. The injuries and deaths among the bicycle riders peak between the ages 9 and 15. Boys are exposed to accidents more than girls. The mortality rate due to bicycle accidents are subjected to the extension of bicycle use on the roads and to the conditions of the roads. The conditions of motorbike accidents are similar to bicycle accidents. The risk factors for the bicycle riders are listed as follows: not to use



helmet, crash with motorized vehicles, to ride bicycle at an unsafe environment, male gender and alcohol and substance use. It is asserted that nonuse of helmet would lead to more severe injuries. The most common injury mechanism is reported as fall from the bicycle. The body parts most frequently injured are the upper extremities. They are followed by the head and neck region. And finally comes the lower extremities. Among severe injuries contusion of brain or intracerebral haematoma due to head trauma, blunt abdominal trauma with laceration or rupture of internal organs are reported. It is indicated that the number of chest and abdominal injuries is increasing recently. Similar to road traffic accidents, bicycle accidents also happen in the afternoon time most frequently (Busuttil, 2009d, Agran et al., 2001, Hyder et al. 2006, Kiss et al., 2010, Acton et al., 1995, Linn et al., 1998, Puranik et al., 1998, Klin et al., 2009, Rivara et al., 1997).

The time spent until the injured reach to the trauma center is critical. The percentage of the nonfatal injuries is striking. Millions of people get hurt in the traffic accidents every year in the world. The data suggest that this number increases dramatically until 2020 in the countries particularly, where the number of vehicles increases rapidly (Chakravarty et al., 2007).

During the investigation of fatal road traffic accidents, the evaluation of factors such as the scene of the collision, witness statements, clothes of the dead, vehicles involved in the accident and the laboratory analysis of the autopsies will be helpful to clarify the accidents (Busuttil, 2009d).

Death due to trauma has a significant place among the childhood mortality. Traffic accident is the most common cause among the mortality due to trauma. Children are exposed to road traffic accidents mostly as pedestrians. Mostly the boys generally in summer are seen as the victims of the traffic accidents due to head trauma. In such traffic accidents socio-economic and ethnic factors play an important role (Newbury et al., 2008, Hyder et al. 2006, Mazurek, 1994). Infant seats, toddler seats and safety seats are found helpful in minimizing the injuries and deaths in the vehicle. It is hard to estimate the next move or behavior of the children when they are on foot (Busuttil, 2009d). The children should not be allowed to play on the roads or among the vehicles. The children should wear helmet, while they are riding bicycle or motorbike. Children should fasten seat belts, while seated in vehicles, or they should use infant seats, toddler seats or safety seats. We can only save our children from traffic accidents by taking such precautions. Furthermore the children and drivers should be more careful in the afternoon time when children are off the school, since traffic accidents happen more frequently in the afternoon time. It is also important to train the children both in the school and at home on traffic.

## 9. Home accidents

Home accidents, occur at home or around the house (Gailerd & Herve 1991). Although home injuries are seen in all age groups, due to being preventable and often, leading up to mortality and morbidity, they are important cause of death for children in both developed and developing countries (Scholer et al., 1997, Harris & Kotch 1992). Among children and adolescents, home accidents are the second most common cause of death after traffic accidents (Jacobsson & Schelp, 1987, Laffoy, 1997).

Home accidents seen in children under 18 years old, are classified as deaths due to poisoning with solid/liquid and gas compounds, falls and blunt trauma, burn, scald or electric shock, drowning and asphyxia, fire arm wounds and stabbing on the basis of "Home

Accident Prevention Inventory" proposed by Tertinger (Tertinger et al., 1984), and has been modified by Asirdizer et al (Asirdizer et al. 2005). Home accidents, are seen in all age groups, especially in children between the ages of 0 and 6 (Asirdizer et al. 2005).

0-6 age group of children, because they spend more time at home, usually in the kitchen, the living room and the bathroom, may face numerous injuries (Bourget & McArtur 1989, Gallagher & Hunter 1995, Kilic et al., 2006). Among children under one year old, drowning and foreign body aspiration and between the ages of 1-4 falling, multiplication, water scalds, flame burns and poisonings are more common. At ages of 2-4, when cleaning agents and drugs are left around; after 5 years old poisonings with drugs stored in the fridge and high places are increasing (Yildirim, 2008).

Home accident types vary according to geographical regions. The most common type of accident is falls and this type of accident is the major cause of childhood injuries and deaths in many regions of the world (Peden et al., 2002, Pomerantz et al., 2001).

### 9.1 Other accidents

Sports injuries, bicycle accidents and some game accidents are among other childhood accidents. Studies indicate that bicycle accidents usually occur in boys and school-age children (Thompson et al., 1990, Cushman et al., 1990).

If accidents and emergency department visits were examined, bicycle accidents are seen as the frequent cause of multiple system injury and also head and brain injuries are the most common cause of death in children accidents (Ji et al., 2006, Guzel et al., 2006, Clarke & Sibert 1986). In order to prevent head trauma, in many countries of the world's and especially in developed countries, helmet use is made compulsory by law for motorcycle and bicycle drivers, but still helmet use of bicycle drivers in developing countries is at a very low level and the rate has been reported to be around 8% (Brown et al., 2002). Mortality rates of bicycle accidents are indicated between 1.2-4.6% (Ji et al., 2006, Heng et al., 2006).

Sports and game injuries in childhood rarely result with sudden death. Evaluation of these cases necessitates the identification of activities prior to death, medical history and detailed autopsy of the deceased (Byard et al. 2002).

## 10. Fall from height

Falls from height are important causes of morbidity and mortality in childhood traumas. According to the reports of the World Health Organization, falls from height rank second among the causes of death in children (Sala et al., 2000, Taviloglu et al., 2001, Peden, 2009). The important factors that affect mortality are patient age, drop shape, floor structure, position of the fall, fall height, the injured tissue and the pathology developing in these organs (Sala et al., 2000, Mathis et al., 2003, O'Neill, 2000, Lallier et al., 1999, Chalmers et al., 1996).

In the United States, each year, more than three million children visit emergency departments because of falling (Committee on Injury and Poison Prevention, 2001). In childhood, falls from height hold an important place in home accidents and occur in the form of falling from staircases, balconies, windows or roof (Yagmur et al., 2004, Lallier et al., 1999, Istre et al., 2003).

Etiology of falls from height may vary due to structural and seasonal characteristics of the countries, regions or cities (Yagmur et al., 2004, Lallier et al., 1999). In the United States, in a study investigating the epidemiology of deaths due to trauma in rural areas, deaths due to

falls from height have been determined as such a large percentage of %20 (Campbell, 1988). In the South Eastern Anatolia region of Turkey, falling from the roof of houses is quite common. In this region, in a related study about falling from the roof, %49,4 of the patients were noted as under 10 years of age and mortality rate was noted as %5,8 (Yagmur et al., 2004).

The risk of accidental fall from height is most common among preschool boys and younger children because their neural control mechanisms, sensory systems and cognitive abilities associated with hazard awareness and avoidance skills are insufficient (Chang & Tsai 2007). According to some studies, the head region is the mainly affected region in the body system (Cassidy et al., 2003, Champion et al., 1989, Potoka et al., 2001, Osmond et al., 2002, Hall et al., 1989). Deaths mostly develop in the early period due to multiple trauma or fatal head trauma (Mosenthal et al., 1995, Buckman & Buckman 1991, Velmahos et al., 1997). In the necropsy studies of Hall et al, head trauma is reported as the most common reason of death in children falls (%70,5) (Hall et al., 1989); because children have a higher head/body ratio than adults (Champion et al., 1989, Buckman & Buckman 1991).

According to the studies about falls from height in childhood, mortality rates are noted between %1,3 and %5,9 (Velmahos et al., 1997, Murray et al., 2000).

## **11. Deaths due to neglect, starvation and physical agents (heat, cold, electricity)**

### **11.1 Neglect- starvation**

Is the situation where fundamental needs of a child like nutrition, health, shelter, clothing, protection and supervision are not properly met by his/her parents (Can et al. 2010). Neglect should be repetitive and should impair the health and development status of the child (Nathanson, 2000).

Accidents rank the first in most cases of child mortality due to neglect. Street accidents (traffic accidents, bicycle accidents, fall from a height), domestic accidents (entrapment in anaerobic places, burns, poisoning, drowning in water), in-car traffic accidents (failure to use child restraints or to put on safety belts, neglecting car maintenance) are the most common ones (Cologlu & Cakalir 1999). It is hardly possible to distinguish between accidental and non-accidental injuries. Post-mortem examination should be performed with relevant post-mortem radiological examination (Nathanson, 2000, Cologlu & Cakalir 1999). The second most common type of neglect is starvation or forced starvation. Starvation can be due to insufficient delivery or non-delivery of food, delivery of improper food, severe loss of appetite or social hunger (Cologlu & Cakalir 1999) Starvation is the condition where there is severe loss of vitamins, minerals, nutrients and energy (Altun & Altun 2010). During the early days of starvation, the glycogen stored in the liver and muscles are used as energy source but glycogen may be understored in children (Altun et al., 2004). As carbohydrates deplete, proteins and fats become the main source of energy. Abundance of fatty acids are formed and transformed into ketone bodies (Altun & Altun 2010, Milroy & Parai 2011). Body mass index drops down. The child gets slim or cachectic. Shortness in height, dehydration, growth and development retardation are noticeable. The skin is dry, atrophic, cracked and hyperkeratotic in appearance. Post-portem examination indicates subcutaneous and internal adipose tissue depletion and atrophy in organs other than the brain. Gastrointestinal organs shrink. Digestive tract is empty; dilatation may be observed in

the gall bladder; hepatic adiposity may be observed (Cologlu & Cakalir 1999, Altun et al., 2004). Diabetes mellitus findings are absent in mortality due to starvation but ketoacidosis may be present in blood (Milroy & Parai 2011). Most of the neglected death cases are under the age of 1 and measurements such as height-weight, head circumference, femur length and sitting height should be done properly and meticulously (Knight, 1996e).

### 11.2 Hypothermia

Hypothermia is the condition when the internal body temperature drops under 35°C. Due to limited thermoregulation in children, tissue oxygenation is reduced in prolonged hypothermia resulting in cardiac arrhythmia (Cologlu & Cakalir 1999, Turk, 2010). Hypothermia mostly occurs in infants during delivery at home. This is also called sklerema neonatorum. In the case of premature infants or infection or congenital heart disease, the infant gets more prone to hypothermia. Since infants have a smaller body mass with higher surface area/mass proportion, they suffer from a rapid temperature loss. Subcutaneous adipose tissue is smaller in infants with underdeveloped vasomotor reflexes. Adolescents, on the other hand, may suffer from failure to feel the cold following sports activities and alcohol intake or may be subject to hypothermia in case of fatigue (Cologlu & Cakalir 1999, Eke & Soysal 1999). Hypothermia and hypoglycemia are mostly the cause of death for infants left out in mosque or church gardens or rich neighborhoods. Post-mortem stains are light pink in autopsy with erosion and hemorrhage in the digestive tract mucosa accompanying hemorrhagic pancreatitis and multi-infarct zones in organs (Cologlu & Cakalir 1999).

### 11.3 Hyperthermia

Hyperthermia is the condition when the body temperature is above 40°C. Hyperthermia may be due to either external reasons (such as heat stroke) or internal reasons (such as infections) (Eke & Soysal 1999). In closed spaces with a high humidity ratio and lack of air flow (such as entrapment in the car in hot weathers) there is a high risk of hyperthermia. Children have a limited thermoregulation capacity when compared to adults. Post-mortem examination indicates non-specific alterations, hyperthermia in internal organs as well as edema in the brain and lungs accompanied with petechial hemorrhages. It is important that both ambient temperature and body temperature are measured during crime scene investigation (Cologlu & Cakalir 1999).

### 11.4 Burns

Mammalian tissues can preserve viability in a relatively narrow window of temperature between 20- 44°C (Eke & Soysal 1999). Child's skin is softer than adults and is more sensitive to heat (Busuttil, 2009c).

Width and depth of the burnt skin surface as well as its proportion to entire body surface affect morbidity and mortality. Burn surface area is determined according to the classical Rule of Nines. Each arm 9, each leg 18, anterior chest 18, posterior chest 18, head 9 and genitalia 1.

1<sup>st</sup> degree: is the burn that affects the epidermis. Presents with erythema and mild pain. Sun burns are a good example.

2<sup>nd</sup> degree: is the burn that affects the epidermis and dermis in varying degrees. Superficial 2<sup>nd</sup> degree burns only invade upper 1/3 of the dermis, and are characterized with blister formation. Deep 2<sup>nd</sup> degree burns, on the other hand, penetrate into lower 1/3 of the dermis. 3<sup>rd</sup> degree burns: are the ones covering the entire epidermis and dermis. (Busuttil, 2009c, Knight, 1996a).

Burns may occur as a result of contact with dry – hot or wet – hot substances or chemicals. The heat damage caused by hot fluids is mostly referred to as scalding. (Busuttil, 2009c, Duke et al., 2011). Burns in children are mostly accidental typically occurring as scalding, but suicide and homicide possibilities should never be overlooked (Hilal et al., 2008). Scalds are severe injuries. Victims generally get to be scalded at home by exposure to hot fluids (Figure 3). There are reports of scalding with boiled milk when making cheese (Cekin et al., 2010). Approximately 10% of abused children have burns and scalds with about 25% of scald injuries resulting from non-accidental reasons (Chester et al., 2006, Jacobi et al., 2010). Abuse-related burns should be differentiated from accidental burns (Figure 4). Arms, face, anterior trunk and neck are risky spots for accidental burns. These are generally asymmetric burns with irregular limits and irregular depth. Abuse-related burns mostly manifest with burns on the thigh and legs, genitalia, hands and feet as glove or sock type burns. These are burns with regular and symmetric limits and depth (Maguire et al., 2008, Maguire, 2010). (Figure 5). Post-mortem examination of a burn case should seek to identify the dead body, indicate cause of death and should try to answer whether the person was trapped alive in fire or not.



Fig. 3. Children are usually scalding accidentally.

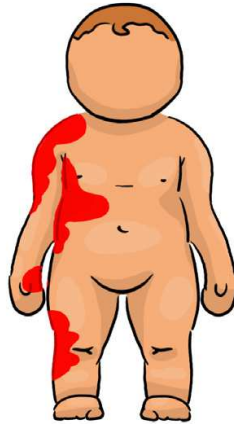


Fig. 4. Accidental burns.

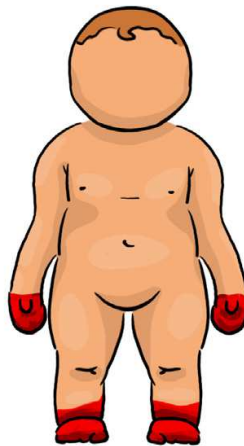


Fig. 5. Abusive burns.

External examination may indicate Pugilistic attitude due to contraction of flexor muscles in upper and lower extremities as a result of denaturation of muscle proteins in exposure to extreme heat. Tissues are dried and toughened due to loss of fluid. There may be bone fractures. Identification of the body may be difficult due to blackened and disintegrated facial features, skin contraction and tightness, scorching of hair and other heat-related changes. Internal examination reveals scalded organs, but the skull may present with extradural hematoma-like, soft, fragmented clots in light chocolate color referred to as heat hematoma (Eke & Soysal 1999, Busuttill, 2009c, Knight, 1996a).

### 11.5 Electric shock

It is the condition when the electric current (electrons) travels over the child's body as they move from one point to another or in other words, when the body becomes a part of the electricity circuit. The biggest obstacle against the electric current is the skin, which has a stronger resistance than the internal tissues of the body (Eke & Soysal 1999). As dry skin has a resistance of 40.000-100.000 ohms, wet skin manifests a resistance of approximately 1000 ohms and callous skin of 2.000.000 ohms (Busuttill, 2009c). Since the child has a thinner skin, it would have a weaker resistance. It generally develops as a result of accidental contact

with an electricity-connected cable. Entry point is generally the hand or the foot, while the exit point is the other hand or the other foot that contacts the ground (Eke & Soysal 1999, Gupta et al., 2009). The most dangerous flow path is the one that goes between the left arm and the right leg. Electricity current may of course run into the body from any spot on the body (Gupta et al., 2009). When it enters the body from the hand, the most important impact that it creates would be the spasm on flexor muscle groups causing a “hold on” effect. As a result, grasping the conductor during electric shock becomes inevitable prolonging the time of electricity to pass the body and worsening the severity of injury (Knight, 1996b). Muscle contractions and spasms may throw away the victim causing extra injuries (Eke & Soysal 1999, Fodor et al., 2011). The origin of the event is mostly accidental in electric shocks that frequently develop as a domestic or occupational accident, and yet the possibility of child abuse or homicide should never be overlooked. It is important to keep the possibility of suicide in mind in adolescent cases (Canturk et al., 2008, Shetty et al., 2010). Death due to electric shock usually develops as a result of ventricular fibrillation or respiratory failure. If the electric current travels through the chest and the abdomen, spasm in intercostal muscles and the diaphragm would cause respiratory paralysis. If it travels through the heart, the result would be arrhythmias, ventricular fibrillation and cardiac arrest. But when it travels through the head and the neck, death would develop as a result of paralysis in the respiratory and circulatory center in the brain stem (Eke & Soysal 1999). There are cases reported with death due to air embolism resulting from electrical injury of neck veins (Kitulwatte & Pollanen 2009). External examination may not indicate any finding in death cases due to electric shock but may as well present with a carbonated body. Electric entry and exit wounds may not always be easily detectable. Entry wound may be in the palms, between the digits, in the oral cavity or in the internal wall of the lips and should be looked for meticulously. Electric burns may present with a grey-white colored parchment look with a typical crater appearance with folded edges. Internal examination indicates non-specific alterations (Eke & Soysal 1999, Polat, 2006).

### **11.6 Lightning strike**

Lightening is the discharge of the electrical potential of the atmosphere between clouds and the earth (Gok, 1983b). With lightening, a DC of 2000- 2 billion Volts gets discharged on earth in an extremely short period of time (in 0,1-1ms) (Busutil, 2009c). Although rare, it may cause an injury as big as crush injuries (Rash, 2008). Lightening strikes generally occur out in the meadows or forests during spring and summer times (Gok, 1983b). Farmers in small settlements and their children as well as swimmers are under risk (Demirel et al., 2007, Kilbas et al., 2008). Death occurs due to burns, respiratory and circulatory arrest. There may be wide burns on the clothing and on the individual. Metallic parts of clothes have gained a magnetization feature. Clothes may be torn apart or shredded (Eke & Soysal 1999). External examination indicates erythema and fumigation and scorching on burn wounds as well as in the hair. Lichtenberg figures may be present on the skin resembling tree branches originating from dilatation and tearing of small blood vessels. (Eke & Soysal 1999, Polat, 2006, Domart & Garet, 2000, Whitcomb et al., 2002). The most common cause of death is cardiopulmonary arrest (Kilbas et al., 2008). Pulmonary edema, contusion, hemorrhage and ARDS may be seen in the respiratory system. Prolonged Q-T, myocardial infarction and Takotsubo’s cardiomyopathy may develop in the heart. Intracranial hemorrhage may be present in the central nervous system (Whitcomb et al., 2002, McIntyre et al., 2010).

## 12. Wounds

All kinds of damage caused on the body by physical or chemical substances are defined as wounds. The features of the damage on the tissue depend on the energy transferred on the tissue, transfer period to the tissue, width of the transfer area, structure of the substance causing injury, impact angle and the status during the impact, the structure of the body part affected and its status during impact. Wounds caused by substances and tools with diverse features display different characteristics. These wounds can be grouped into five. 1- Blunt traumatic wounds, 2- incised wounds (sharp object wounds), 3- Penetration wounds, 4- penetrating stab wounds, 5- incised & crush wounds (Cetin, 1999, Knight, 1996f).

All the physicians involved with forensic medicine should be familiar with the characterization and images of the wounds. Fatal childhood wounds alone will be assessed here. Blunt traumatic wounds: might be observed as abrasions, ecchymosis, hematoma, laceration and bone fractures (Cetin, 1999). This group of wounds is commonly observed and coexist in deaths due to general body trauma related wounds such as traffic accidents and falling down from height. Internal body, major vessel and medulla spinalis wounds might be fatal (Cetin, 1999, Bilgen et al., 2009). These might be caused by an accident or occur as a result of homicide and neglect. Ecchymosis is the most common abuse wound (Maguire, 2010). Existence of many abrasions, bruises and hematomas can not be assessed as an abuse finding alone. Toddlers and active school age children might have plenty of ecchymosis especially on knees, pretibial area and forehead (Nathanson, 2000). Abrasions with a particular shape and ecchymosis might be helpful in terms of understanding the cause of the wound (Gok, 1983b).

Bite marks, ecchymosis and laceration or combination of three might be observed. Marks should be measured and teeth structure should be defined via the remaining teeth marks in order to assess the possibility that marks may be caused by the bites of another child or an animal (help of the forensic dentist is of value) (Nathanson, 2000).

Existence of many fractured bones is a strong evidence of abuse. Medium shaft fractures, spiral or oblique fractures of long bones, metaphyseal and epiphyseal fractures and smashes, periosteal thickening, numerous rib fractures, linear fractures on skull especially on parietal bone and compression fractures are associated with abuse (Maguire, 2010, Nathanson, 2000, Knight, 1996c).

Incised wounds, penetration wounds, penetrating stab wounds, sharp incised & crush wounds associated mortality might be caused by an accident or a homicide. Suicide is also a possibility for the adolescent groups. Localization and number of the wounds and wound age are important in understanding the cause of the wound. Crime scene investigation, social and medical history of the child and post mortem examination findings should be interpreted together (Ekizoglu & Arican 2010).

## 13. Firearm fatalities

Injuries are leading causes of mortality throughout the world both for childhood and other age groups (Fraga et al., 2010, Meel, 2007). Firearm fatalities are the most common causes of traumatic death together with deaths from motor vehicle crashes in countries like USA. In 1992, 5367 children and adolescents aged 1 to 19 years were killed by firearms. 63% were the victims of homicides, 27% of suicides and 9% of unintentional injuries. In contrast, during that same year in Britain, firearms were involved in a total of 46 deaths (Mazurek, 1994).



There is a steady nationwide increase in the death toll from firearms and the USA still lacks effective gun control legislation (Mazurek, 1994, Powell et al., 1996). For example, firearms are easily available in the USA and Scandinavian countries (Canturk et al., 2010). Firearm fatalities are common in countries like Columbia, South Africa and Brazil while it is quite low in Japan. Firearm fatalities are more common in countries which legally ensure easy access to firearms and have low-to-mid income level (Meel, 2005). Firearm fatalities are higher among men and the age group 15-44. Minority youth are disproportionately affected by firearm homicides. Availability of firearms at home is reported to increase the risk of firearm fatalities for children and adolescents. Firearm fatalities among children are rarer under the age of 10. The incidence is progressively higher for the age groups 10-14 and 15-19 (Fraga et al., 2010, Meel, 2007, Mazurek, 1994, Powell et al., 1996, Canturk et al., 2010, Meel, 2005, Presley et al., 2007, Grossman et al., 2005, Canturk et al., 2007, Agran et al., 2001).

Fatalities might occur due to negligent behavior with firearms, children playing with firearms and during hunting or firearm cleaning process. Children might shoot themselves or might be shot by a family member or a friend. Pistols are the most common causes of death among other firearms. Shotgun and rifle follow the pistols as a fatality cause (Heninger & Hanzlick 2008, Barber et al., 2002, Bhattacharya et al., 1998). Firearms are mostly to blame for homicides and suicides among children (Mazurek, 1994, Canturk et al., 2007).

Firearm fatalities manner of death is mostly homicide for children. (Meel, 2005, Heninger & Hanzlick 2008, Byard et al., 2009, Sorenson & Berk 1999, Eber et al., 2004). A study which compares the pediatric firearm fatalities in Australia and USA reports that the ratios vary; however, fatalities are more frequently seen among men, the cases are more common respectively as manner of death, homicide, suicide and accidental deaths; the most frequently injured body part was reported to be the head (Byard et al., 2009).

Easy legal access to firearms in some developed countries increases the risk of suicide committed with firearms especially for the adolescents (Canturk et al., 2010, Meel, 2005, Portzky et al., 2005, Grossman et al., 1999). The pediatric suicide risk increases together with the increase in age. The fatal and violent forms of suicide are preferred by boys (Canturk et al., 2010). Hanging is reported to be the most common manner of pediatric suicide. Suicides committed via firearms increase during adolescence and young adulthood (Canturk et al., 2010, Madge, 1999).

Unintentional firearm fatalities are experienced less among children when compared to homicides and suicides. These are sometimes taken as suicides. Children might accidentally die as a result of a bullet fired out of the firearm by family members or aggressors. Access to firearms at home increases the pediatric risk of injury or death. Children or adolescents may lead to an accident while trying to impress others or children might die during the firearm cleaning process or hunting (Grossman et al., 2005, Barber et al., 2002, Karger et al., 2002, Hemenway et al., 2010).

In a study from Istanbul, most of the cases (n=36, 53.4%) were aged 16-20 years (Asirdizer et al., 2010). Firearms other than handgun, rifle, shotgun may cause childhood mortality. Nonpowder firearms are not toys. These may cause serious injuries or fatalities among children and adolescents. 32 of 39 nonpowder gun-related (ball-bearing guns, pellet guns, air rifles, paintball guns) deaths reported in USA between the years 1990 and 2000 were among children less than 15. It is estimated that 3.2 million nonpowder guns are sold every year in USA (Laraque, 2004, O'Neill et al., 2009). A study reports that 16 of 59 simply modified blank cartridge gun related deaths within 4 years occurred among the ages of 11-

20 (Uzun et al., 2009). Nonpowder firearms and blank cartridge guns related child deaths most frequently occur among men as it is the case for other firearm deaths; head injuries are the most common type while most of the cases are suicide cases (Laraque, 2004, O'Neill et al., 2009, Uzun et al., 2009). Celebratory gun shooting injuries are mostly seen among men in metropolitans and crowded places during celebrations or festivals and holidays. However, there are rare cases of women or child injuries or deaths (Ozdemir & Unlu 2009).

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#### 15. References

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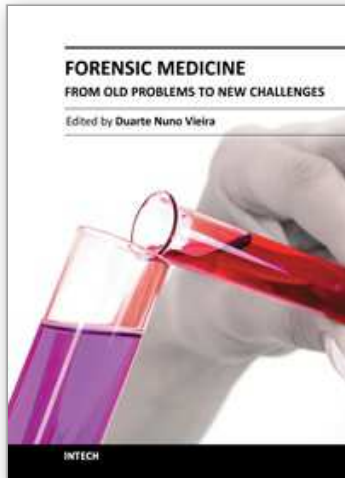
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Phone: +86-21-62489820  
Fax: +86-21-62489821

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