If the kidney is intact, the pathologist may order an analysis of the kidney for the presence of Y chromosomes.[88] In the test, the technician examines the nuclei of the cells to determine what percent of the nuclei contain Y chromosomes. Research indicates that a count higher than 10% is strongly indicative that the decedent was male.[89]

Many pathologists consider additional criteria in sexing skulls. For example, the male brow is more developed than that of the female while the male chin is more square than that of the female. In addition, the rim of the female eye socket is sharper than that of the male. Costal cartilage calcification patterns,[90] nasal features,[91] the Mandibular Canine Index,[92] and other dental features.[93]

Race

After identifying the decedent's sex, the anthropologist may attempt to determine the decedent's race.[94] The shapes of the long bones or skull are clues to the decedent's race.[95] The anthropologist can usually differentiate on the basis of the slope and appearance of the facial

88. Thomsen, "Sex Determination of Severely Burned Bodies," 10 Forensic Sci. 235 (1977).

89. *Id.* at 241. *See also* Duffy, Skinner & Waterfield, "Rates of Putrefaction of Dental Pulp in the Northwest Coast Environment," 36 J. Forensic Sci. 1492 (1991) (the sex chromatin test).

90. Rao & Pai, "Costal Cartilage Calification Pattern — A Clue for Establishing Sex Identity," 38 Forensic Sci. Int'l 193, 201 (1988) (although the authors recommend the use of the test, they emphasize that the method is "best practiced [as] a screening test").

91. Macho, "Descriptive Morphological Features of the Nose — An Assessment of Their Importance for Plastic Reconstruction," 34 J. Forensic Sci. 902 (1989).

92. Rao, Rao, Pai & Koitan, "Mandibular Canine Index — A Clue for Establishing Sex Identity," 42 Forensic Sci. Int'l 249 (1989) ("Accuracy of sex determination identity was found to be 84.3% in the male and 87.5% in the female").

93. DeVito & Saunders, "A Discriminant Function Analysis of Deciduous Teeth to Determine Sex," 35 J. Forensic Sci. 845 (1990).

94. Taylor, DiBennardo, Linares, Goldman & DeForest, *supra* note 85, at 798.

95. Bucklin, *supra* note 58, at 202; Sledzik & Ousley, "Analysis of Six Vietnamese Trophy Skulls," 36 J. Forensic Sci. 520 (1991); Johnson, O'Higgins, Moore & McAndrew, "Determination of Race and Sex of the Human Skull by Discriminant Function Analysis of Linear and Angular Dimensions," 41 Forensic Sci. Int'l 41 (1989); Holland, "Use of the Cranial Base in the Identification of Fire Victims," 34 J. Forensic Sci. 458 (1989) (the cranial base can be used to determine the race of skeletalized individuals, but some pathologists believe that shrinkage during fire can preclude the application of the technique to fire victims; these researchers found that the average shrinking in a low temperature burning such as the average house fire "does not significantly impair the accuracy" of this identification technique); Iscan, Loth & Wright, "Racial Variation in the Sternal Extremity of the Rib and its Effect on Age Determination," 30 J. Forensic Sci. 452 (1987); Holland, "Race Determination of Fragmentary Crania by Analysis of the Cranial Base," 31 J. Forensic Sci. 719 (1986).

bones, the breadth and length of the skull, and nasal features. In Caucasians, the shape of the palate tends to be triangular; in members of the Negroid race, the shape is often round or rectangular.[96]

Age

The anthropologist may also be able to furnish a rough estimate of the decedent's age at the time of death. There are numerous indicators of age. Several techniques are based on osteology, or the study of bones.[97]

One technique is based on the analysis of centers or points of ossification. Bones form from these centers. As the years pass, the centers gradually unite with the main portions of the bone. It is said that the epiphysis of the bone fuses.[98] The centers and portions unite in a relatively regular sequence. Until the person reaches 25 years of age, the stage of ossification allows the anthropologist to determine age within a year or two.

In addition, certain divisions in the skeleton disappear as the years pass.[99] For example, the sutures in the skull close. Skull suture fusion is, in general, an unreliable method for determining age with the exception of the basilar suture.

The symphysis in the pubic area is another indicator. The symphysis is the joint between the left and right pubis. Some anthropologists have attempted to devise formulae for predicting age based on an analysis of the symphysis.[100] Other degenerative changes in bones can also be helpful clues to the age of the decedent.[101]

Gill, Hughes, Bennett & Gilbert, "Racial Identification from the Midfacial Skeleton with Special Reference to American Indians and Whites," 33 J. Forensic Sci. 92 (1988).

96. *Bucklin, supra* note 58, at 202.

97. M. Iscan, *Age Markers in the Human Skeleton* (1989); Stout, "The Use of Histomorphology to Estimate Age," 33 J. Forensic Sci. 121 (1988); Ubelker, "Estimating Age at Death from Immature Human Skeletons: An Overview," 32 J. Forensic Sci. 1254 (1987).

98. *Id.*

99. Mann, Jantz, Bass & Willey, "Maxillary Suture Obliteration: A Visual Method for Estimating Skeletal Age," 36 J. Forensic Sci. 781 (1991); Gruspier & Mullen, "Maxillary Suture Obliteration: A Test of the Mann Method," 36 J. Forensic Sci. 512 (1991); Mann, Symes & Bass, "Maxillary Suture Obliteration: Aging the Human Skeleton Based on Intact and Fragmentary Maxilla," 32 J. Forensic Sci. 148 (1987); McCormick & Stewart, "Age Related Changes in the Human Plastron: A Roentgenographic and Morphologic Study," 33 J. Forensic Sci. 100 (1988); O'Halloran & Lundy, "Age and Ossification of the Hyoid Bone: Forensic Implications," 32 J. Forensic Sci. 1655 (1987).

100. Snow, "Equations for Estimating Age at Death from the Pubic Symphysis: A Modification of the McKern-Stewart Method," 28 J. Forensic Sci. 864 (1983).

101. Murray & Murray, "A Test of the Auricular Surface Aging Technique," 36 J. Forensic Sci. 1162 (1991).

The teeth also develop in a predictable progression. Hence, the sta of dentition such as the molars is evidence of age.[102] This is especial reliable in infants and children. The baby teeth are referred to a deciduous dentition.[103] The first baby teeth erupt at approximately si

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102. Xiaohu, Philipsen, Jablonski, Weatherhead, Pang & Jiazhen, "Preliminar Report on a New Method of Human Age Estimation From Single Adult Teeth," 5 Forensic Sci. Int'l 281 (1991); Ohtani & Yamamoto, "Age Estimation Using th Racemization of Amino Acid in Human Dentin," 36 J. Forensic Sci. 792 (1991 Kashyap & Rao, "A Modified Gustafson Method of Age Estimation from Teeth," 47 J Forensic Sci. 237 (1990) (the Gustafson method estimates age based on "certai regressive changes in the hard tissues of the anterior teeth").

In 1990, the California legislature enacted California Welfare & Institutions Code § 680 reading:

> In any case in which a person is alleged to be a person described in Section 601 or 602, or subdivision (a) of Section 604, and the age of the person is at issue and the court finds that a scientific or medical test would be of assistance in determining the age of the person, the court may consider ordering an examination of the minor using the method described in "The Permanent Mandibular Third Molar" from the Journal of Forensic Odonto-Stomatology, Vol. 1: No. 1: January-June 1983.

There is currently a controversy whether by enacting this statute, the legislature manifested its intent that a proponent of testimony estimating age based on an examination of the third molar would not need to lay the normal evidentiary foundation for the testimony. Reply to People's Answer to Minor's Opposition to Court Order Pursuant to Welfare & Institutions Code Section 608, in the Matter of Juan Lopez, No. 116-531 (Juv. Div., Cal. Super. Court, San Francisco Cty.). In the *Lopez* case, the prosecution's expert, Dr. Michael Barkin, claimed that the technique was "99.9% accurate at the point of being 6 months within a person's actual age." *Id.* at 5. However, in the article cited in the above statute, the researcher, Dr. Nortje, conceded that "[i]f we estimate the age of an individual child in a given root stage as the average age for that root stage, the resulting estimate may differ from the true age by as much as 29 months in some cases because of the observed statistical variation about the average." 1 J. Forensic Odonto-Stomatology 31. Further, in Forensic Dentistry 116 (1976), Dr. Irvin Sopher cautions that in the 14 to 23 year range, "the skeletal structures rate superior to the teeth in relation to chronological age estimation." It remains to be seen whether the courts will interpret the new statute as obviating the need for compliance with normal foundational requirements and, if not, whether this technique will pass muster under the normal standards. *See* Alex, "Welfare and Institutions Code Section 608: A Kelly-Frye Nightmare," 18 California Attorneys for Criminal Justice Forum 21 (May/June 1991) ("This statute is dangerous and should not be construed to give Kelly-Frye acceptance to a method whose reliability in the scientific community has not been established. Such results are inconclusive, preliminary in nature, and subject to several variables. For the purpose of age determination, the admissibility of expert testimony based upon the application of this technique does not pass the ... test of Kelly-Frye and, consequently, is not admissible in a court of law ....").

103. Bass, Forensic Anthropology (unpublished manuscript on file with the National College of District Attorneys, Bates College of Law, University of Houston,

months; all the deciduous teeth should have erupted by two years of age. Between the sixth and eleventh year, the typical person begins to replace deciduous teeth with adult dentition. The first molar may erupt at six years, the second at age 12, and the third at 18. Computerized image analysis is now being used to enhance the accuracy of age estimates based on examination of teeth.[104]

A microscopic examination of the core of skeletal bones is further evidence.[105] The analyst measures the osteons or canals in the core of the bone.[106] Analysis of femoral cores appears to yield more accurate age estimates than the cores of tibia or humeri.[107] An age estimate, based on microscopic techniques, may be accurate to a plus or minus five year range.[108]

Preliminary research indicates that the quantification of certain minerals present in bones (iron, zinc, phosphorous, magnesium, lipids, cholesterol, and proteins) may also furnish valuable clues to dating bones.[109]

There has also been research on the question of whether age estimates can be based on the metamorphosis of the rib.[110] The researchers devised a system of nine phases that the extremity progresses through and attempted to correlate ages with the phases. They concluded that an examination of the morphology of the rib is helpful in estimating age. Other researchers are investigating the use of analysis of chest plate X-rays to determine age.[111]

Houston, Texas). *See also* Kumar & Sridhar, "Estimation of the Age of an Individual Based on Times of Eruption of Permanent Teeth," 48 J. Forensic Sci. 1 (1990); Miller, Dove & Cottone, "Failure of Use of Cemental Annulations in Teeth to Determine the Age of Humans," 33 J. Forensic Sci. 137 (1988).

104. Lopez-Nicolas & Luna, "Application of Automatic Image Analysis (IBAS System) to Age Calculation. Efficiency in the Analysis of Several Teeth from a Single Subject," 50 Forensic Sci. Int'l 195 (1991); Kambe, Yonemitsu, Kibayashi & Tsunenari, "Application of a Computer Assisted Image Analyzer to the Assessment of Area and Number of Sites of Dental Attrition and Its Use for Age Estimation," 50 Forensic Sci. Int'l 97 (1991).

105. Thompson, "Microscopic Determination of Age at Death in an Autopsy Series," 26 J. Forensic Sci. 470 (1981).

106. *Id.* at 471.

107. *Id.*

108. Bucklin, *supra* note 58, at 202.

109. Castellano, Villanueva & von Frenckel, "Estimating the Date of Bone Remains: A Multivariate Study," 29 J. Forensic Sci. 527 (1984).

110. Iscan & Loth, "Determination of Age from the Sternal Rib in White Male: A Test of the Phase Method," 31 J. Forensic Sci. 122, 131 (1986) ("The present study suggests that age can be successfully estimated to within a phase of the actual age of the rib"); Iscan, Loth & Wright, "Age Estimation from the Rib by Phase Analysis: White Females," 30 J. Forensic Sci. 853 (1985).

111. Barres, Durigon & Paraire, "Age Estimation from Quantitation of Features of 'Chest Plate' X-Rays," 34 J. Forensic Sci. 228, 232 (1989) (the authors assert that this

Occupation

Unusual osteological features can also enable the anthropologist to identify the occupation of the decedent.[112] For example, in one case, an osteological pathology on the right shoulder of the skeleton helped the anthropologist determine that the decedent had spent significant time working as a citrus fruit picker.[113]

Stature

Finally, the anthropologist can estimate the individual's stature from skeletal remains. The anthropologist measures the dimensions of the long bones and compares the measurements with existing charts.[114]

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method compares favorably to Iscan's method of determining age on the basis of rib analysis).

112. Weinker & Wood, "Osteological Individuality Indicative of Migrant Citrus Laboring," 33 J. Forensic Sci. 562 (1988).

113. *Id.*

114. Bucklin, *supra* note 58, at 202; Giles, "Corrections for Age in Estimating Older Adults' Stature from Long Bones," 36 J. Forensic Sci. 898 (1991) ("Because in the 20th century stature has gradually increased in virtually all populations, the apparent decrease in stature of older people is a composite: an actual stature decrease incident to aging ... and a decrease attributable to the fact that the maximum stature attained by older people is less than that attained by adults born later in the century ...."); Giles & Hutchinson, "Statureand Age-Related Bias in Self-Reported Stature," 36 J. Forensic Sci. 765 (1991) (after measuring a decedent's stature, the pathologist usually compares it with the reported stature of the suspected decedent; for example, the pathologist may consider the height reported on the suspected decedent's driver's license; however, there are indications that many persons, particularly short persons, overestimate their height when they report it); Willey & Falsetti, "Inaccuracy of Height Information on Driver's Licenses," 36 J. Forensic Sci. 813 (1991); Abdel-Malek, Ahmed, El Sharkawi & El Hamid, "Prediction of Stature from Hand Measurements," 46 Forensic Sci. Int'l 181 (1990) (measurements of hand length and hand breadth); Badkur & Nath, "Use of Regression Analysis in Reconstruction of Maximum Bone Length and Living Stature from Fragmentary Measures of the Ulna," 45 Forensic Sci. Int'l 15 (1990); Simmons, Jantz & Bass, "Stature Estimation from Fragmentary Femora: A Revision of the Steele Method," 35 J. Forensic Sci. 628 (1990); Giles & Klepinger, "Confidence Intervals for Estimates Based on Linear Regression in Forensic Anthropology," 33 J. Forensic Sci. 1218 (1988); Rao, Gupta & Sehgal, "Determination of Length of Human Long Bones of Hands from Their Fragments," 40 Forensic Sci. Int'l 279 (1989); Robbins, "Estimating Height and Weight from Size of Footprints," 31 J. Forensic Sci. 143 (1986); Tibbetts, "Estimation of Stature from the Vertebral Column in American Blacks," 26 J. Forensic Sci. 715 (1981). *But see* Kahane & Thornton, "Discussion of 'Estimating Height and Weight from Size of Footprints,'" 32 J. Forensic Sci. 9 (1987); Galloway, "Estimating Actual Height in the Older Individual," 33 J. Forensic Sci. 126 (1988); Kodagoda & Jayasinghe, "A Preliminary Test of Pearson's Formula for Estimation of Height of Sri Lankans," 36 Forensic Sci. Int'l 241 (1988); Lundy, "A Report on the Use of Fully's Anatomical Method to Estimate Stature in Military Skeletal Remains," 33 J. Forensic Sci. 534 (1988).

The femur is particularly useful in making the estimate. New research suggests that reliable estimates can also be based on the dimensions of the vertebral column.[115] Foot and shoe measurements can also assist in estimating stature.[116]

§ 19-5. Cause of Death.

After identifying the decedent, the pathologist focuses on the question of how the decedent died. This question has three aspects: the cause of death, the mechanism of death, and the manner or mode of death. This section deals with the first aspect, cause of death (COD).

§ 19-5(A). Blunt Force Injuries.

Blunt force injuries produce both external and internal lesions. Although many injuries contain features of all three, individual wounds can usually be subdivided into contusions, abrasions, and lacerations.

A common blunt force lesion is a contusion or bruise. A bruise is caused by blunt trauma generally to the surface of the body. Force can be transmitted internally to cause bruising of internal organs in tissues. Thus, a bruise may be located remote to the point of impact. In this type of injury involving the skin, there is no break in the skin. However, the force disrupts blood vessels below the skin and causes tissue hemorrhage. The blood exits or extravasates from the damaged vessels and infiltrates the tissue. The action of certain enzymes and the decomposition of hemoglobin causes the color of the bruise to change over time. At first, the bruise might appear red to violet. Within three days, the color could change to dark blue. Within five to seven days, the bruise may take on a greenish appearance. Within eight to 10 days, the bruise may turn yellow; and in 13 to 18 days, the skin would return to normal. However, it must be recognized that the healing of a bruise shows considerable individual variability.

The next significant blunt force injury is an abrasion. An abrasion occurs when a blunt force scrapes the external surface of the body. The force removes the skin surface and denudes or exposes the area. There is ordinarily little bleeding accompanying an abrasion. The most important forensic implication of an abrasion is that it indicates a

115. Lundy, "Sacralization of a Sixth Lumbar Vertebra and Its Effect upon the Estimation of Living Stature," 33 J. Forensic Sci. 1045 (1988).

116. Giles & Vallandigham, "Height Estimation from Foot and Shoeprint Length," 36 Forensic Sci. Int'l 1134 (1991); Jasuja, Singh & Jain, "Estimation of Stature from Foot and Shoe Measurements by Multiplication Factors: A Revised Attempt," 50 Forensic Sci. Int'l 203 (1991).

point of impact. There are four basic types of abrasions. A scratch occurs when a pointed object passes over the skin and moves a layer of skin in front of the object.[117] Second, an impact (pressure) abrasion occurs when an object is stamped against the skin, as when tire tread moves over skin surface.[118] A friction (sliding) abrasion is caused by linear pressure on the skin if the pressure is accompanied by movement.[119] If a rough object comes in contact with a wide area of skin surface, the abrasion is occasionally termed a brush burn, although it is somewhat of a misnomer.[120]

A third common type of external lesion is a laceration. Here the skin surface and often the underlying tissue are torn. Internal structures can also be lacerated. There are several types of lacerations.[121] Splitting occurs when the skin is crushed between two hard objects such as skull and rock.[122] If the skin is in a relatively fixed position when the force is applied, overstretching resulting in tearing can occur; a kick to the head might cause this type of laceration. Lacerations can also result from grinding compression.[123] When a car runs over a body, the compression might cause avulsion, actual separation of skin from underlying tissue. Simple tearing can be caused by irregular or sharp objects such as a stick.[124] Lastly, chop injuries with features of cuts and lacerations are inflicted by heavy-edged instruments such as hatchets.[125] The shape of the laceration may give a clue to the type of object that caused the laceration.[126] If the object has a blunt round end which strikes the body, the laceration will often have a stellate or star shape. If the object has an edge, as in the case of a hammer, the laceration may have a crescent shape. A linear round object such as a metal rod will produce a linear laceration with a Y at the very end.

Blunt force capable of causing serious external lesions may produce major internal injury. A person can have a serious internal injury from blunt trauma with only mild or no apparent external injury. A common injury would be a fracture of a bone,[127] a break in the bone's continuity.

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117. Case, Blunt Force Injuries (unpublished manuscript on file at Department of Pathology, St. Louis University Medical School).
118. *Id.*
119. *Id.*
120. *Id.*
121. *Id.* at 3.
122. *Id.*
123. *Id.*
124. *Id.*
125. *Id.*
126. *Id.*
127. Zni-Jin & Jia-Zhen, "Study of the Microstructures of Skull Fracture," 50 Forensic Sci. Int'l 1 (1991) (the utility of the scanning electron microscope in studying skull fractures).

There are several types of fractures.[128] If a fracture produces a single break without other fragmentation of the bone, the fracture is termed simple. If there is other fragmentation, the fracture is called multiple or comminuted. If the fracture breaks skin, the fracture is termed open or compound.

In addition to the fracture of bones, blunt trauma may cause internal bleeding by disruption of internal organs or vascular structures. The bleeding itself is termed hemorrhage.[129] If the escaping blood collects in tissue or a body space to form a localized mass, the collection is called a hematoma.[130]

Blunt Force Injuries to the Brain

An understanding of brain injuries requires an appreciation of the composition of the brain and its coverings. The outermost skin covering is often termed the scalp, it covers the skull which encases the brain with its protective membranes. The layer of membrane closest to the inner skull surface is the dura, the next layer the arachnoid, and the final layer the pia mater. These three layers serve as protective coverings for the cerebrum, which is what most laypersons have in mind when they use the expression, "brain." In reality, the brain consists of the cerebellum and brainstem in addition to the cerebrum.

There are numerous types of intracranial injuries. An epidural or extradural hematoma can occur between the skull and the dura.[131] A hematoma in this region is normally caused by a fracture. A fracture tearing the middle meningeal artery can cause severe bleeding, leading to coma and death — in some cases rapidly.[132]

A subdural hematoma can develop in the space between the dura and the arachnoid.[133] Symptoms may not become manifest until days after the trauma.

A subarachnoid hematoma can occur between the arachnoid membrane and the brain. Although subarachnoid hemorrhage commonly occurs in a head injury, extensive subarachnoid hemorrhage often results from natural disease processes affecting the intracranial arteries such as ruptured aneurysms.

Epidural, subdural, and subarachnoid hematoma are sometimes referred to as extracerebral lesions. There are also intracerebral lesions directly involving the cerebrum. A concussion is a state of

128. Wecht, *supra* note 19, at 25-29.
129. *Id.*
130. *Id.*
131. *Id.* at 25-23.
132. *Id.*
133. *Id.* at 25-54.

temporary unconsciousness produced by a head injury. A contusion (a bruise of the brain) is a more severe injury; the period of unconsciousness, if present, is often longer, and there may be minor hemorrhaging.[134] The most severe injury would be a full laceration or tearing of the brain.[135] Lacerations can lead to intracerebral hematomas.[136] A coup injury occurs on the side of the brain which sustained the impact of the blunt force. However, since the cerebrum has some mobility within the skull, contrecoup injuries are possible. These injuries occur on the side of the head opposite the impact. Predominantly coup injury suggests a moving object striking a stationary head (being struck with a hammer) while predominantly contrecoup injuries suggest that the moving head struck a fixed surface (tripping and striking the head on a sidewalk).

Battered Child Syndrome

Children are not only particularly vulnerable to blunt force injuries; child abuse is so widespread that unfortunately, children are frequently subjected to such injuries.[137] The high incidence of multiple fractures and subdural hematoma in children was first noted by Caffey in 1946.[138] In 1962, Kempe coined the term, "battered child syndrome."[139]

There are several different types of abusers.[140] The intermittent abuser batters the child periodically, but there are periods of proper care between batterings. A one-time abuser may be stopped either by his own sense of self-restraint or by the child's death. Constant abusers batter the child frequently because of the abuser's impulsive immature personality or outright hatred for the child.[141] An ignorant abuser inflicts injury on the child because the abuser does not understand the probable effect of his or her conduct on the child.[142] In an example cited by Wecht and Larkin, a mother poured pepper down her child's throat because she had heard that the pepper would stop the child's crying without harming the child.[143]

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134. *Id.* at 25-55.
135. *Id.*
136. *Id.* at 25-56.
137. *See generally* Wecht & Larkin, "The Battered Child Syndrome," in *Legal Medicine* 1980 31 (C. Wecht ed. 1980).
138. *Id.*
139. *Id.*
140. *Id.* at 32.
141. *Id.* at 33.
142. *Id.* at 34.
143. *Id.*

The injuries inflicted on children by abusers include, among others, abrasions, lacerations, fractures, and contusions.[144] The injured parts of the child's body often include the head, abdomen, and chest.[145] The abdomen may be injured when the abuser delivers a kidney punch to the child.[146] A head injury may result if the abuser shakes the child too hard. If the abuser squeezes the child hard, there may be a chest or abdominal injury. There may also be retinal hemorrhages and subdural hemorrhage of the optic nerve.[147]

As noted in § 19-10, many courts now permit forensic pathologists to testify not only that a child's body exhibited certain injuries but also that those injuries are characteristic of battered child syndrome. Some pathologists use the following criteria to determine whether the syndrome is present: The child is under three years of age; there is evidence of several bone injuries sustained at different times; there are subdural hematomas; the case history given the hospital by the child's custodian does not fit the wound pattern; and there is evidence of neglect of the child.[148] Each case must be evaluated by correlating the investigative and physical findings. Many pathologists are reluctant to use these criteria as the basis for an opinion that the particular child in question was subjected to abuse; rather, they confine their testimony to opinions that the injuries are characteristic of abuse and do not fit the explanation offered by the parent or caretaker.

§ 19-5(B). Sharp Force Injuries.

There are three basic types of wounds that can be inflicted by sharp-edged instruments: cuts, stabs, and chops.

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144. *Id.* at 35-38; Paul, "The Medical Examination in Sexual Offences against Children," 17 Med. Sci. Law 251 (1977) (the article details the type of examination which the expert should conduct to determine whether the child has been subjected to abuse.

145. Fossum & Descheneaux, "Blunt Trauma of the Abdomen in Children," 36 J. Forensic Sci. 47 (1991); Wecht & Larkin, *supra* note 137, at 39-41.

146. *Id.* at 41.

147. Riffenburgh & Sathyavagiswaran, "The Eyes of Child Abuse Victims: Autopsy Findings," 36 J. Forensic Sci. 741 (1991); Rao, Smith, Choi, Xiaohu & Kornblum, "Autopsy Findings in the Eyes of Fourteen Fatally Abused Children," 39 Forensic Sci. Int'l 293, 299 (1988) (such hemorrhages "are not common in non-abused children").

148. Matusinka, Prosecution of Domestic Violence Cases (unpublished manuscript on file with the National College of District Attorneys, Bates College of Law, University of Houston, Houston, Texas). Diagnostic radiologists can help establish the cause and date of the child's bone fractures. Brown, Fox & Hubbard, "Medical and Legal Aspects of Battered Child Syndrome," 50 Chi.-Kent L. Rev. 45 (1973).

A cut is sometimes called an incised wound; it leaves a sharp defe in the skin.[149] In a cut, the length of the wound is generally greate than its depth. Cut wounds are ordinarily relatively superficial.

In a stab wound,[150] the depth of the wound usually exceeds its lengtl A stab can be caused by either a sharp-pointed instrument such as a ice pick or an instrument such as a knife with a sharp edge.

Chopping wounds are inflicted by instruments such as axe cleavers, and hatchets. Chops are usually larger wounds than eithe cuts or stabs and are frequently associated with fractures of th underlying bones.

A careful examination of a knife wound may enable the forensi pathologist to reach several conclusions. At the outset, the pathologis may be able to determine whether the instrument that caused th wound had one or two sharp edges.[151] If the instrument had a singl sharp edge, the stab wound will have a point at one end, but it will b blunt at the other end.[152] If the instrument had a double-sharp edge the wound will have two sharp points.[153]

The pathologist may also be able to estimate the length of the instrument that caused the wound.[154] The pathologist measures the depth of the wound, the distance from the skin surface to the apex of the wound. A knife, however, can create a stab wound much longer than its blade.[155] The reason is that when the knife is pushed into the body, the skin tissue compresses. It would be difficult for a two-inch knife to create a ten-inch wound. Thus, the pathologist can exclude some weapons with relative confidence, but it is virtually impossible to determine the exact length of the instrument. Obviously, if the blade was only partially inserted, the wound track will be shorter than the blade.

The pathologist can also estimate the width of the blade that caused the knife wound. However, due to skin elasticity, here too the estimate is only a general approximation, not an exact determination. More accurate determinations of the width of the blade can be made if a stab wound through a bone is identified.

The location of some wounds — "defense wounds" — may indicate the victim was trying to defend himself during the assault. However, the pathologist cannot tell if the assailant is right- or left-handed.

149. *See* Clark, Sandusky, Hawley, Pless, Fardal & Tate, "Fatal and Near-Fatal Animal Bite Injuries," 36 Forensic Sci. Int'l 1256 (1991) (bites by pit bulls).
150. Hunt & Cowling, "Murder by Stabbing," 52 Forensic Sci. Int'l 107 (1991).
151. Bucklin, *supra* note 58, at 211.
152. *Id.*
153. *Id.*
154. *Id.* at 212.
155. *Id.*

The pathologist should be able to determine the direction of the stab. If the stab cuts through thick fat underlying the skin, the slant of the wound canal may indicate the direction from which the stab came.[156]

The wound may be caused by an arrow. An arrow wound can closely simulate a bullet wound.[157] However, arrow wounds have distinguishing features.[158] Bullet wounds are discussed in the immediately following subsection.

§ 19-5(C). Gunshot Wounds.

Pathologists are often called on to analyze gunshot wounds. The Federal Bureau of Investigation estimates that firearms are involved in approximately two-thirds of all homicides in the United States.[159] Any discussion of gunshot wound pathology must begin with the observation that when a pistol or rifle fires, several types of material exit the barrel. The material that travels the farthest is the bullet itself. Powder also leaves the barrel, but it does not travel as far as the bullet. Next, soot exits the barrel. Finally, flames and gases reach a short distance beyond the end of the barrel. These materials help the forensic pathologist to analyze gunshot wounds and, on the basis of that analysis, make certain determinations.

Types of Gunshot Wounds

Gunshot wounds fall into two categories: entrance and exit wounds.

Entrance wounds. Pathologists classify entrance wounds on the basis of the distance between the skin surface and the muzzle when the weapon discharged. At any range, the entry of the bullet into the skin causes two effects: a hole and an abrasion collar[160] or margin. As the bullet stretches the skin and pushes its way into the body through the skin, it scrapes away some of the outer layer of the skin around the edge of the hole. This rim is called the abrasion collar. However, the characteristics of these effects and other features will vary, depending on the range of the shot.

156. Wecht, *supra* note 19, at 25-44.

157. Hain, "Fatal Arrow Wounds," 34 J. Forensic Sci. 691 (1989).

158. Randall & Newby, "Comparison of Gunshot Wounds and Field-Tipped Arrow Wounds Using Morphologic Criteria and Chemical Spot Tests," 34 J. Forensic Sci. 579, 585 (1989) (the wounds differ with respect to the shape of the central defect and the presence of both abrasion rings and wipe-off material such as lead deposits).

159. Bucklin, *supra* note 58, at 203.

160. Randall & Jaqua, "Gunshot Entrance Wound Abrasion Ring Width as a Function of Projectile Diameter and Velocity," 36 J. Forensic Sci. 138 (1991) ("The authors postulate that abrasion width is a function of the ratio of projectile velocity and the maximum deformation velocity of the target skin").