POST COLLISION VEHICULAR FIRES

DETERMINATION OF PROBABILITY OF OCCUPANT SURVIVAL POST IMPACT

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In the year 1999 a representative of a major automaker in the United States made the statement that if an individual survives the collision he or she should not die as the consequence of a post collision vehicular fire.

Herein lies the problem. Did the occupant survive the collision? Did the occupant sustain injuries that even though the fire and/or its consequences may have played a role in the death was this occupant going to die from collision injuries regardless?

The answers to the above questions are rarely simple and most often very difficult to determine. The answer to this question involves the consideration of information and data from multiple sources and areas of scientific expertise.

Ultimately, the answer to this question quite often lies within the field of forensic medicine and pathology.

In every state within the United States and virtually every foreign country, the Institutes of Forensic Medicine and Pathology are those scientific and medical resources, charged by law, to determine cause and manner of death, and to piece together the circumstances of death that might aid in the resolving of questions such as this.

Unfortunately the level of expertise of all forensic pathologists is not equal.

Some forensic pathologists train in areas where there are very few cases and where there is no real hands on training by skilled professionals with multiple years of experience in these areas.

In many training programs there is no cross over with other experts and specialities which would allow the forensic pathologist to have a better understanding of potential consequences of various types of vehicle crashes.

More time is spent in teaching the novice forensic pathologists about overt homicides, suicides, drug deaths, and various types of natural deaths than in the area of motor vehicle crash fatality investigation.

Once an “official report” is generated by a local medical examiner-forensic pathologist, this report becomes the document of record to indicate the cause and manner of death.

This report and its author’s opinions also can be used in courts of law to determine and answer questions concerning the death of the individual.

Since the medical examiner is typically a local, state, or county official, there is extreme credibility built into the opinions and conclusions of this individual.

These opinions may be frequently in error, or based on information without sufficient facts to justify the conclusion.

It is very difficult for anyone, despite their level of expertise, credibility, or additional fact base to overcome the opinions of the local official. It is equally, if not more difficult, even with the presentation of new information, new facts, and the discussion of the “state of the art investigative techniques” to alter the opinions of the local medical examiner.

Enough said about the difficulties of dealing with jurisdictional professionalism and local expert opinion.

How does one approach the problem of trying to determine whether or not an individual first, survived the collision impact, and finally, did the fire or its consequences either cause or play a major roll in the death of an individual.

As an ancillary issue, the discussion of potential pain and suffering associated with severe injury or death in these circumstances often needs to be addressed.

In order to solve the above puzzle numerous pieces must be accumulated and placed into their proper positions to see the picture of what has happened to the occupant.

FIRST PIECE OF THE PUZZLE:

COLLISION DYNAMICS:

A full understanding of the collision dynamics is usually necessary in order to determine whether or not there is probability of survival post impact.

The single most important parameter that universally is relied on to determine potential survivability is the velocity change and Delta V.
This is most unfortunate since although extremely important in analyzing the crash dynamics and

determining survivability, the velocity change in and of itself can be very misleading.

In trying to determine the importance of the Delta V the accident type must first be considered.

Frontal collisions, or variances thereof, predominate accident modes. These are followed by lateral impacts, rear impacts and rollovers.

The velocity change has very little importance in a pure rollover, whether it be a lateral rollover, a corner to corner, or even an end over end. Rollover events typically are less injurious to occupants assuming that they are contained within the vehicles occupant capsule and that the capsule does not collapse. This is because the energy of the rollover is typically dissipated over great distances and over a significant period of time or pulse.

There is no focal point in the rollover for energy to be concentrated on the occupants. Typical vehicle to ground velocity changes are in the range of 6 mph.

The automotive medical literature supports the above. Except for the occurrence of neck injuries, that frequently are associated with loss of vertical occupant space, contained occupants typically suffer no significant head injuries, deceleration injuries of the chest or abdomen or even complex orthopedic injuries.

In rear end collisions extremely high velocity changes, even exceeding 50 mph, can be sustained without significant injury. This assumes the occupant is contained and maintained in their seated position, and that the occupant restraint features such as the seatback, restraints and the interior friendliness do not fail to adequately protect the occupant.

Lateral impacts are more complex, most especially for the near side occupants. There is very little space between an impacting vehicle, environmental structure, and the occupant with only 4 to 6 inches inside the door panel or side panel of most vehicles. Delta Vs of 30, 35 and 40 for a near side lateral impact have much greater significance typically than a similar impact in the front of the vehicle or even the rear.

At what Delta V can one assume that the occupant would have died simply from collision forces?

There is no absolute answer to this question. The type of collision, whether the occupant is restrained, whether there are airbags present in the vehicles all are factors which must be considered in answering this question.

In the early 1980s a major automotive manufacturer stated that with a properly functioning three point restraint system that an occupant can survive a 50 mph Delta V without life threatening injury assuming the occupant cabin can remain intact. Indeed, there are numerous examples of individuals in frontal, offset frontal and angled frontal collisions that survive impacts where the velocity change is close to or even exceeds 50 mph. This does not include individuals whose vehicles are equipped with airbags.

In rear end collisions it is not unusual for occupants to survive collisions where the striking vehicle is traveling in excess of 50 mph.

The reality is, however, that once the velocity change begins to exceed 40 mph in a frontal collision the effectiveness of a simple three point restraint system drastically is reduced.

If one adds an airbag to the three point restraint system, and assumes that the restraint system is functioning appropriately, then survivability of an occupant in a vehicle whose interior is not significantly compromised is not unreasonable at Delta Vs of 40 to 50 mph.

In frontal type collisions it should be expected that a three point restrained occupant would survive a 30 to 35 or high 30 Delta V without significant injury assuming no significant passenger compartment intrusion.

The Federal Government actually mandated this with the institution of the Federal Motor Vehicle Safety Standards in the late 1960s.

In fact, the Federal Government assumed that the auto manufacturers could design and build a vehicle in which an unbelted occupant in a vehicle that ran into a wall at 30 mph would survive with no injury exceeding an Abbreviated Injury Scale level of 3. This would mean that the occupant would not have significant brain damage, quadriplegia, paraplegia or fatality. This occupant would survive because of the friendliness of the interior, from the ride down of the steering assembly, the instrument panel and the other interior structures designed to not only provide comfort for the occupant but to protect the individual.

The time over which the velocity change is occurring is also extremely important. This is often referred to as the "Crash Pulse".

A typical 30 to 35 mph barrier type crash, or vehicle to vehicle impact, has a crash pulse of approximately 100 to 110 milliseconds.

A rollover with the trip speed of 35 mph may have a pulse of several seconds.

A rear end collision of 30 mph, because of the "softness" of the rear end, may have a pulse somewhat different from a frontal.

An underride collision may have a lengthened pulse because of the underride prior to actual abrupt deceleration of the vehicle.

In general, the longer the pulse the more able the occupant physiologically is able to accommodate the velocity change.
A race car driver hitting the wall at an angle in a frontal collision at 150 mph has reasonable

probability of sustaining a life threatening or fatal injury. The same race driver careening off the wall and overturning a dozen times may get out and walk away from his vehicle.

The next important aspect of the crash dynamics is the determination of the primary direction of force (PDOF).

This is the vector through which the greatest resultant force acts on the center of gravity of the vehicle. This vector may vary slightly for different occupant positions within the same vehicle.

In general the occupants will want to follow the primary direction of force vector. In a pure frontal collision the occupants will move forward. In a 30 degree right or left angle frontal collision they will move to the right or left at approximately 30 degrees, in a lateral impact they will move 90 degrees to the left or right and in a rear end collision move rearward relative to the vehicles motion.

It must be remembered that although the vehicle and occupants obey the basic laws of physics including Newton’s Laws, in the real world steering wheels and columns, center consoles, friction between the occupant and the seat, slight variations in occupant position, even variations in occupant mass distribution can effect the real world actual movement of the occupant.

Once one knows the approximate velocity change, pulse of the crash, and primary direction of force, conclusions can be reached concerning the predicted occupant motion in the vehicle in each crash situation being investigated. This is often referred to as the occupant kinematics.

With the determination of occupant motion, the potential impact points within the vehicle can be determined.

The front windshield glass is quite force limiting. It is unrealistic for an adult to sustain fatal injury in an impact with the windshield glass.

This is untrue of the windshield header where extreme spikes in Gs can occur to the head of an occupant striking the header.

Depending on the type of A pillar and its force attenuating capabilities the A pillar and instrument panel in some cases can be relatively occupant friendly.

Side window glass in most vehicles is tempered or safety plate and is unable to produce fatal injuries in most cases for occupants impacting these structures.

It is also unreasonable that the seatback which contained the occupant could cause a life threatening or fatal injury by the occupants interaction with it. However, the occupants interaction with the rear seat cushion or seatback after a seatback collapse can create serious life threatening injury for an occupant in rear end or rear end type collisions.

<u>SECOND PIECE OF THE PUZZLE:</u>

RESTRAINT ISSUES:

SEATBELTS:

Whether the primary vehicle's restraint system is in use at the time of the crash is very important.

This is often a very difficult question to answer since the fire can not only destroy seatbelt webbing but forensic evidence on retractors, latchplates and restraint hardware such as shoulder anchor D rings and latchplate D rings.

Although on occasion the latchplate is still found engaged within the buckle, the fact that the latchplate is no longer present in the buckle should not be construed to be <u>proof</u> that the occupant was unrestrained.

Once the springs become hot within the buckle and once the fire has burned away and melted the plastic components, instead of "melting together" often the latchplates drop out of the buckles. High pressure water hoses may dislodge latchplates from buckles and move the two considerable distances one from the other.

Typically, the "soft structures" of the vehicle are degraded by the fire. However, witness marks on steering wheel rims, instrument panels, A pillars and other vehicle structural members can sometimes be seen to indicate that an occupant may have moved in an unrestrained manner into such structure.

Assuming restraint, and considering the primary type of collisions, primary direction of force, Delta V and crash pulse, assumptions can be made as to the potential survivability of the occupant.

Consideration for type of restraint is important since three point restraints have a much greater ability to protect the occupant than two point shoulder restraints, automatic shoulder and manual laps, or two point lap belts.

AIRBAGS:

Driver's side airbags have been common since 1990 and were in some vehicles prior to this. In vehicles of late 90s manufacture and current year model vehicles there may be 8 different types of airbags in such vehicles.

The deployment of airbags in various crash situations even for unbelted occupants, usually increases the likelihood of survival with any impact despite the velocity change.

In fact, for unbelted occupants the degree of protection afforded by the airbag is even greater than that for the belted occupant since the restraint system plays the primary role of occupant protection till velocity changes begin to meet and exceed 30 mph in frontal crashes.

PUZZLE PIECE #3:

EYE WITNESS ACCOUNTS:

Although often frought with error, the accounts of individuals who observe the crash, who are present to try to render aid, or are actually involved in the collision itself, are extremely important to consider.

What these individuals say has to be tempered with the other pieces of the puzzle in order to ascertain their validity.

Although it has been alleged by some “experts” that the fire can cause the body to sit up in the vehicle, to make somewhat seemingly purposeful movements with hands, arms, and torso, this is not correct. If a witness sees this, it almost always equates with post collision survival.

Extreme heat precipitates protein within muscles, causes foreshortening of bone and muscle, and as the body incinerates, the hands and arms can be drawn into what is called the pugilistic pose. There is nothing about the fire, however, that can cause the torso to sway back and forth, the head to turn, an arm to raise up and then go down or movement such as this.

There may be sounds associated with the fire within the vehicle from fluids and air escaping from hoses and containers, and even some discrete sounds associated with the degradation of the tissues of the occupants. It is usual for the scream of an occupant, or the vocalizations of an occupant, to be misconstrued as these other sounds.

Often times there are conflicting reports of various witnesses. It is here that the consideration of the other forensic evidence might help one to decide which witness is more accurate in their description of what has occurred.

It is also very important to consider the fact that all witnesses do not have the same line of sight, proximity to the occupant or the vehicle, and confrontation with the occupant and vehicle at the same time.

A person who comes upon the vehicle finds the occupants unmoving and goes for help may not be present when the victims basically comes to, becomes more aware, and begins to scream, verbalize or move as the fire and heat increase within the occupant cabin. A second passer-by, witness or someone who has remained behind may see this where the initial observer has left the immediate area.

PUZZLE PIECE #4:

THE VICTIM:

Vehicle fires reach exceedingly high temperatures, the ambient air approaches 1,200 to 1,800 degrees Fahrenheit and temperatures of flame actually 2,500 +/- degrees Fahrenheit.

When a body is cremated for burial, temperatures of approximately 1,200 to 1,400 degrees Fahrenheit for several hours are reached. This is capable of reducing a 150 pound person to several pounds of ash.

In most vehicle fires the occupant, although exposed to these temperatures, is not exposed for the same period of time or length.

However, the typical victim removed from a vehicle fire following a collision is charred.
The degree of burn severity is defined as either first, second, third, or fourth degree or charring.

Charring is a post mortem phenomena. The individual in virtually every case has expired before the full body charring has occurred.

However, focal or localized charring does occur in individuals who survive fires.
The mere fact that the body is charred does not prove that the individual died either from the fire or from impact injury.

As the body is thermally degraded the skin is often burned away. Subcutaneous adipose tissue-fat, muscle and bone are exposed and burned. The muscle and skin may split.

It is not unusual for the anterior rib cage and sternum to be partially or fully burned away exposing the contents of the chest or abdomen.

Frequently intestines may extrude or protrude from the bird's breech of the torso wall.

The above is not a product of some antemortem trauma but the typical consequence of extreme heat.

In fact, in virtually every medical examiner's office files, one can find cases in which victims of house fires in which people have died in bed, in a chair or on a sofa, or on a floor, who have received no injury of any type, no blunt injury of any type, whose bodies look just this way.

Burned skeletal segments or bone typically exhibit severe fragmentation.

Bone is comprised of collagen. Collagen provides tensile strength. Hydroxy apatite crystals provide compressive strength or hardness. Extreme heat causes the collagen to dehydrate decreasing the elasticity of bone which alters the structural lattice work of the bone creating shrinkage, distortion and deformation.

Various types of heat induced fractures have been classified as longitudinal, transverse, either curved or straight, patina and delamination type.

Pre-fire traumatic fractures are defined by the basic beam theory and are caused by an application of load to a given span. These fractures, especially in a long bone, develop where stress exceeds the tensile strength of the material.

The skull is a complex bone having an outer table and inner table.

Typically fire fractures to the skull consist of multiple radiating lines. Often times the outer table is so fragile that it will crumble, and in transportation of the body from accident site to morgue or funeral home the entire cranial vault may be lost.
An unsuspecting pathologist seeing the body for the first time in the morgue with the entire brain exposed may incorrectly conclude that a severe traumatic fracturing of the skull has occurred.

Extreme caution must be exercised by any individual, including the pathologist, when doing an external or post mortem examination on a charred body. A severely fragmented skull, collapsed and burned away facial bones, exposed deep structures of the neck, exposed body cavities, fractures of the wrist, forearms, legs and ankles as well as femurs are typically seen in bodies that have been charred and exposed to extreme heat whether the individual died in a house fire or a vehicle related fire.

During the observation of a body and in an autopsy there may be findings that aid in determining whether the individuals died from impact or survived and died as the consequence of fire.

The absolute indicator of whether there has been brain injury is actually finding injury to the brain or to the various coverings of the brain.

Although fire itself may cause epidural hemorrhages and in some cases subdural hemorrhages, a subdural hemorrhage at the base of the skull is unusual as a consequence of fire. A fracture through the base of the skull is less typical than those involving the cranial vaults. Contusions to the brain and intracerebral hematomas are evidence of pre-fire trauma.

Small focal pinpoint or microscopic hemorrhages in the brain can be associated with extreme heating of the brain.

Localized collections of soft tissue bleeding or hematoma often are important in ascertaining whether a rib fracture was antemortem or post mortem. Hemorrhage within the pleura, the lining of the chest cavity, associated with rib fractures is indicative of antemortem trauma as well.

The condition of the heart in the pericardial sac is important. A laceration to the anterior surface of the heart may be consistent with a severe or high Delta V injury. This should not be confused with a charred anterior surface often seen when the sternum and ribs burn away.

A transected aorta would be a very rare complication of fire. The observation of such is diagnostic of a significant or high velocity change typically associated with frontal or angled frontal impacts.

Fractures of the vertebral column are important to ascertain. Severe fracture subluxations of the thoracic spine and/or cervical spine are typically indicative of antemortem trauma.

However, in a severely burned body moving or transportation of the body may fracture the axial skeleton. In a body that has been burned, buried and exhumed, significant artifact may exist associated with the head and neck complex, the neck and the thoracic spine.

Rupture of the diaphragm should be looked for at autopsy. This should not be confused with cases in which the anterior chest and abdomen have simply been burned away and the anterior crux of the diaphragms accordingly burned.

Blood clot and hemorrhage in the psoas muscles along the lumbar spine, within the pelvis and collections of blood within the abdominal and chest cavities are important indicators of pre-fire trauma.

It is typically not difficult to determine an antemortem laceration of the liver or spleen assuming that decomposition does not follow the fire. In such cases the spleen is often times liquified or semi-liquified.

Since the kidneys are truly retroperitoneal and protected within a capsule, finding hemorrhage around these structures or within the capsule is important in determining any significant intrusive abdominal injury.

Pelvic fractures are rare from fire except where the anterior pubic ramus is exposed and burned. The finding of fractures in the pelvic skeleton is important in ascertaining the presence or absence of antemortem trauma.

Long bone fractures, as stated earlier, are often difficult to evaluate. An atypical location for fire fractures would include the proximal humerus, proximal radius and ulna, proximal femur, and mid and proximal tibia and fibula. Even these areas, however, may sustain post mortem fracture from extreme heat.

Collision forces should be considered by the pathologist in trying to determine whether complex fractures or trauma are consistent with the accident events. If they are not there is a real probability that they are artifactually created by heat.

The pathologist should also consider that multiple occupants in the same vehicle, although they may be exposed to slight variations, if velocity changes, G forces, and primary force vectors, that they all are within the same vehicle environment and see at least a similar accident.

If one occupant sustains considerably more trauma than another, the pathologist should look further to see if this is just artifact for this individual or whether there is some reasonable explanation given the condition of the vehicle and the crash dynamics to explain marked differences in the observations from one victim to another.

When a fire occurs, depending on the structure being thermally degraded, varying degrees of partially degraded debris enters the ambient air. These particles present in the form of carbonaceous and other materials. An occupant breathing air laden with such particles may have soot deposited in the oral cavity, above the vocal cords, below the vocal cords, and in the tracheobronchial tree.

The absence of this material does not exclude life or survival post impact. The position of the occupant in vehicle, the amount of air current, air currents moving the soot cloud away from the occupant space, can determine the amount of soot that may or may not be in the airway.

The condition of the lungs otherwise is important in that the superheated air once it reaches a temperature of approximately 300 degrees F. is damaging the lining of the lungs. This damage results in an outpouring of fluid into the air spaces, bleeding into the air spaces, and an increase in the weight of the lungs. The findings of increased lung weight, fluid and blood in the lungs in a victim in an automotive fire is a very important indicator of post collision survival.

At autopsy the condition of the soft tissue, viscera, and intervascular blood should be observed by the pathologist. If it appears to have a cherry red or somewhat of a pink hue this would be consistent with an elevation of blood carboxyhemoglobin.

Once the carboxyhemoglobin approaches 15 to 20 % saturation the tissues begin to exhibit this color variation. Also alteration in consciousness can occur, including disorientation.

In all fires, varying degrees of carbon monoxide are produced. The more available oxygen is, the more efficiently the structure being consumed is fully degraded, the less carbon monoxide will be produced.

In a residential house fire where the victim may be contained in a bedroom, living room, etc. smoke fills the structure often before flames reach the victim. Very high levels of carbon monoxide in the ambient air are reached and typically the blood carboxyhemoglobin in such victims may reach 70 to 80% saturation.

This is very different in victims of automotive fires.

In my own office we have investigated numerous instances of well documented post vehicle crash survival, the victims have been fully autopsied, and full toxicology run where the carboxyhemoglobin levels are negative or very low.

Every forensic pathology text cautions the pathologist and scientist not to conclude that an individual was dead from impact forces simply because carbon monoxide levels are low or even zero, especially in those cases related to chemically fueled fires such as post collision vehicle fires.

It is typical in such cases to have very low levels of carboxyhemoglobin, even zero levels, it is rare to find levels exceeding 30% saturation.

There are numerous explanations for this.

First, the vehicle is out in the open air with large amounts of oxygen continuously available. This produces the hottest fire, a faster burning fire and one that produces less carbon monoxide.

Wind currents moving through and around the vehicle change the carbon monoxide and soot accumulation in the ambient air associated with the vehicle occupants.

Flame may actually reach the occupant much sooner in a vehicle fire than a house fire and cause severe respiratory shock and cardiovascular collapse prior to significant levels of carbon monoxide or soot reaching the lungs.

It is important to know whether the occupants in the vehicle were smokers, and whether one or more were smoking in the vehicle.

Smokers typically do not have carbon monoxide levels above about a 6% saturation although there are spurious reports of up to 13%.

In a non-smoker or in a vehicle where the individuals were not smoking, any elevation of carbon monoxide above several percent saturation is important.

Carbon monoxide enters the blood solely by active respiration. It is not absorbed through the skin or by any other route before or after death. Carbon monoxide cannot diffuse into the lungs after death and attach to the hemoglobin molecule, elevating the blood carboxyhemoglobin.

In the blood of the people who have survived the collision, in breathing the fumes of the fire there are other toxic substances which may be present and typically cannot enter the blood stream of a deceased individual. Cyanides predominant, they are present when plastics degrade. Nitric oxide, phosgene and other more complex substances may be liberated from plastic polymers and can generate toxic gases.

<u>PUZZLE COMPLETED?</u>

In summary, the determination of post collision survival and whether death has occurred as the consequence of a vehicle fire is a complex issue.

In some cases a post mortem examination and autopsy may stand alone in answering this question.

In many cases, however, even with a post mortem and autopsy, the additional information accumulated in the investigation is extremely important and necessary in making such a determination.

There may be cases in which without an autopsy there is enough accumulative information from other sources to determine that there is reasonable probability that the person survived the crash, and that fire, within a reasonable degree of forensic, medical, and scientific probability caused the death of the individual.

The training, experience and case involvements of the expert are extremely important considerations that one must consider when trying determine the reliability of conclusions and opinions concerning this complex issue.

Fire can mask many types of death including homicides, suicides and natural deaths. It is only by the work of a skilled and trained investigator that the answers from the dead in such a case can be heard.

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