Fatal traffic accidents and forensic medicine

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ABSTRACT

In the event of a traffic accident fatality, the death is reported as an “unusual death,” an inquest is conducted, and, if necessary, a forensic autopsy is performed to prove any causal relationship between the accident and the death, identify the vehicle at fault, and determine the cause of the accident. A forensic autopsy of a traffic accident fatality needs to both determine the cause of death and identify the mechanism of injury, an analytical task that requires observation of three major traffic accident factors: the body, the vehicles involved, and the scene of the accident. Also crucial to determining the cause of death is the process of looking into whether the people involved in the accident had any diseases that might affect their driving performance or were under the influence of alcohol or drugs. In order to reduce the number of people killed in traffic accidents, it will be important to promote joint research uniting forensic medicine, clinical medicine, automotive engineering, and road engineering, take measures to limit the impact of inebriated pedestrians and pedestrians suffering from dementia, and ensure proper screening of alcohol and illegal drug consumption in drivers.

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1. Introduction

Forensic medicine represents one of the medical sciences and plays a prominent role in the investigation of human deaths. Traffic accidents account for the majority of accidental deaths worldwide. The determination of the causes and manners of deaths is an important issue in the investigation of traffic victims. Forensic autopsies of the victims, alcohol and drug analyses of the drivers, and DNA analyses of the specimens help identify causes of death and identify causes of traffic accidents. In this review, we first survey the medico-legal management of traffic accident victims in Japan and then propose ideas for reducing the number of traffic accident fatalities from the perspective of forensic medicine.

2. The relationship between traffic accidents and forensic medicine

Professionals in the field of forensic medicine strive to make fair, scientific medical judgments, advocate for the individuals involved, and help make society a safer and more secure environment when working on legal cases that require medical explanation. Traffic accident fatalities fall into this category, making them an important focal point in the discipline of forensic medicine.
Unusual deaths (reportable deaths).

1. No known natural cause of death
2. External cause of death
   1. Unintentional deaths
      a. Transportation accidents
      b. Exposure to smoke, fire, and/or flames
      c. Falls
      d. Threats to breathing
      e. Drowning and submersion
      f. Poisoning and exposure to noxious substances
      g. Abnormal environment (high or low environmental temperatures, abnormal atmospheric pressure, etc.)
      h. Electrocution and lightning
      i. Natural hazards
      j. Electrocution and lightning
      k. Poisons and exposure to noxious substances
   2. Intentional deaths
      a. Suicide
      b. Homicide
   3. Medical malpractice

Medical Practitioners Act does not stipulate exactly what an external cause of death to the police department with jurisdiction. Although the Article 21 of the Medical Practitioners Act requires the physician to report

Deaths fall into two main groups: “usual deaths” and “unusual deaths”. The most common example of a death in the former category would be a person who has an illness (an endogenous disease) and dies in a hospital from the effects of his or her condition—in other words, an "endogenous death" that occurs during the course of medical treatment. In the event of a death that falls into the “unusual” category, meanwhile, Article 21 of the Medical Practitioners Act requires the physician to report the death to the police department with jurisdiction. Although the Medical Practitioners Act does not stipulate exactly what an “unusual death” is, the category covers traffic accident fatalities and all other exogenous deaths (Table 1). A traffic accident is an accident that involves any mode of transportation, be it a car, bicycle, ship, or airplane [15].

All traffic fatalities are reported as unusual deaths and subjected to police inquests. If necessary, a judiciary process called a “forensic autopsy” is then performed to prove whether the victim died of injuries sustained in the accident, identify the vehicle at fault, and determine the cause of the accident. Forensic autopsies come in two types: judicial autopsies, which are performed for criminal deaths in forensic medicine departments at university faculties of medicine and medical schools across the country, and administrative autopsies, which are performed for non-criminal deaths in medical examiner’s offices in the 23 wards of Tokyo, Yokohama City, Nagoya City, Osaka City, and Kobe City; in all other areas, autopsies of this second type are performed as administrative autopsy-compliant “autopsies with the consent of the family” in forensic medicine departments. Under the “Act on Investigations, etc., regarding Cause of Death and Identity of Dead Bodies Handled by the Police, etc.,” enacted in April 2013, autopsies designed to investigate non-criminal deaths are now performed in forensic medicine departments nationwide (death investigation autopsies). Police and medical examiners select the applicable autopsy type based on the circumstances of the death in question (Fig. 1, Table 2).

1. Natural death in hospital
2. Unusual death (reportable death)
   a. Postmortem inspection (external examination)
   b. Non-criminal cases
      i. No autopsy
      ii. Administrative autopsy
      iii. Death investigation autopsy
   c. Criminal cases
      i. Judicial autopsy

Fig. 1. Medico-legal management of death.
up onto the hood or front windshield of the vehicle in a medium-speed collision (with the vehicle moving 20–60 km/h), and thrown into the air and then brought to the ground in a high-speed collision (with the vehicle moving 60–100 km/h). A low-speed collision often results in the pedestrian being run over by the vehicle involved, while high-speed collisions can cause severe head trauma when the pedestrian hits the road surface [1,3,11,14].

Injuries to the driver and passengers occur if the vehicle collides with another vehicle or a structure off the side of the road, causing parts of the car to bruise the people inside it, if the vehicle tips over, and if people inside are thrown from the vehicle. The driver sometimes sustains a handle injury or suffers a severe injury such as a cardiac rupture if his or her chest smashes into the steering wheel, but a seat belt helps prevent the driver from hitting the steering wheel, ramming into the front windshield, and flying out of the car, which can cause massive trauma. Determining whether the people involved were wearing their seat belts at the time of the accident is thus an integral part of any investigation [2,9]. Seat belts are also vital when airbags deploy; in an accident resulting in airbag deployment, the airbag can expand rapidly into the passenger’s chest and cause serious injury. As making clear distinctions between the driver and the passengers helps locate liability for the accident, the driver identification process represents an important diagnostic step in the field of forensic medicine. Linear abrasions caused by seat belt compression—marks known as “seat belt signs”—help identify the seating positions of the occupants.

Investigators working on a forensic autopsy for a traffic fatality have to diagnose the cause of death and determine the mechanism of injury, a process that demands careful observation of the three major factors in an accident: the body, the vehicles involved, and the scene of the accident. In addition to being an integral part of advocating for the individuals involved and preserving peace and order, forensic autopsies also represent a fertile context for uncovering basic research topics that might spur the development of forensic medicine as an academic discipline. From our experiences in forensic autopsies on traffic fatalities, we have identified problems for basic research on the diagnosis and pathological conditions of brain damage and researched methods for verifying hypotheses via animal studies [12,13,17]. Given that brain damage is one of the most common and most severe outcomes of traffic accidents, understanding proper diagnostic procedures and accurate pathological conditions can be tremendously helpful in saving lives.

4. Diseases and driving

There are two basic types of conditions and symptoms that a person can develop while driving a car: diseases that may cause the sudden, unexpected death of the driver and diseases and symptoms that may affect the driving performance of the driver (Table 4). A “sudden, unexpected death” is one in which a healthy individual unexpectedly develops an endogenous disease and dies within 24 h of initial onset. Heart disease, which accounts for the majority of sudden, unexpected deaths, can develop while an individual is driving. Although heart disease can indeed kill a driver, most drivers who develop heart disease are not allowed to drive cars to the extent allowed by their doctors. In the event of a sudden, unexpected death of a driver, investigators often perform an autopsy to differentiate the death from a normal traffic accident fatality. However, diseases and symptoms that may affect the driving performance of a driver seldom become the subjects of forensic medical examinations; although they may help trigger traffic accidents, they almost never actually cause the death of a driver operating a vehicle [3,4,5,6,7,10].

5. Driving under the influence of alcohol and drugs

The law prohibits driving a motor vehicle under the influence of alcohol or drugs because doing so impairs the driver’s judgment and
makes it difficult to operate the vehicle normally. Driving under the influence of alcohol corresponds to driving with a blood alcohol content of at least 0.3 mg/mL or a breath alcohol content of at least 0.15 mg/L (under Article 44, Paragraph 3 of the Order for Enforcement of the Road Traffic Act). A person’s breath alcohol content is equivalent to roughly 1/2000th of his or her blood alcohol content (Table 5; [8,11]).

Blood alcohol content and breath alcohol content have no bearing on “drunk driving,” however, which is a state in which a person is unable to drive normally because of alcohol in his or her system. In a normal traffic accident, investigators can determine whether the driver was under the influence of alcohol as long as they can measure the person’s breath or blood alcohol content at the time of the accident. In a hit-and-run, though, investigators have little to go on because there is simply no way to obtain alcohol content readings from the driver when or shortly after the incident occurs. Cases where the driver sustains an injury are problematic, too: an ambulance takes the driver to the hospital, making it impossible for investigators to get alcohol content measurements at the time of the accident. In our department, we have used gas chromatography–mass spectrometry and high-performance liquid chromatography–tandem mass spectrometry to perform simultaneous qualitative analyses for approximately 300 types of drugs, including banned substances, psychoactive drugs, and sleeping pills, to determine whether the corresponding drivers were under the influence of drugs at the times of their respective accidents (Fig. 2).

6. DNA analysis and traffic accidents

DNA type, or the characteristics of an individual person’s unique deoxyribonucleic acid sequences, is represented by the number of repetitions of a particular sequence in a particular locus, the presence of a particular sequence, and other variables. When examining a hit-and-run incident, any match between the victim’s DNA type and a DNA type found in bloodstains or tissue fragments from a suspect vehicle is an extremely valuable piece of evidence for identifying the vehicle involved in the incident. ABO blood type is known in most people and used as a target for screening vehicles. We have developed a new method.

<table>
<thead>
<tr>
<th>Stage</th>
<th>BAC (mg/mL)</th>
<th>BrAC (mg/L)</th>
<th>Degree, signs, and symptoms of intoxication</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.1–0.5</td>
<td>0.05–0.25</td>
<td>Exhilaration: tipsy feeling</td>
</tr>
<tr>
<td>1</td>
<td>0.5–1.0</td>
<td>0.25–0.5</td>
<td>Weak intoxication: mild inebriation</td>
</tr>
<tr>
<td>2</td>
<td>1.0–1.5</td>
<td>0.5–0.75</td>
<td>Slight intoxication: pleasant, talkative, stimulated mood</td>
</tr>
<tr>
<td>3</td>
<td>1.5–2.5</td>
<td>0.75–1.25</td>
<td>Moderate intoxication: impaired judgment, difficulty walking</td>
</tr>
<tr>
<td>4</td>
<td>2.5–3.5</td>
<td>1.25–1.75</td>
<td>Strong intoxication: slurred speech, clouded consciousness</td>
</tr>
<tr>
<td>5</td>
<td>3.5–4.5</td>
<td>1.75–2.25</td>
<td>Severe intoxication: loss of consciousness, decreased body temperature</td>
</tr>
<tr>
<td>6</td>
<td>&gt;4.5</td>
<td>&gt;2.25</td>
<td>Coma: circulatory failure, respiratory paralysis, death</td>
</tr>
</tbody>
</table>

Large variations of signs and symptoms exist among individuals in each alcohol concentration.

Table 5
Blood alcohol concentration (BAC), breath alcohol concentration (BrAC), and degree of intoxication.

![Fig. 2. Gas chromatography–mass spectrometry (GC-MS) analysis of amphetamine and methamphetamine.](image)
7. Ideas for reducing the number of traffic accident fatalities

1) In the field of forensic medicine, examinations of traffic accident fatalities are judicial procedures. However, the insight into causes of death and other medical information that forensic autopsies can reveal is useful in preventing sudden deaths and treating injuries in clinical medicine. Analyses of the mechanisms behind bodily injuries also shed light on the relationships between people, vehicles, and roads, making them valuable resources that experts in the fields of automotive and road engineering can use to improve cars and road environments. Thus, efforts to promote joint research projects that unite forensic medicine, clinical medicine, automotive engineering, and road engineering in exploring traffic accident fatalities will help reduce the number of traffic accident fatalities.

2) Initiatives aimed at preventing traffic accidents involve measures designed to combat drunk driving and mitigate the effects of dementia in drivers, among other strategies. Still, experience has shown that the causes of traffic accidents are often pedestrians in inebriated states or suffering from dementia. Considering that pedestrians frequently sustain severe injuries in traffic accidents, delineating the physical factors affecting pedestrians and devising countermeasures accordingly could bring the number of traffic accident fatalities down in the future.

3) The blood alcohol content levels of trauma patients who were drivers in recent traffic accidents should be measured at medical institutions. If there is a significant lapse of time between an accident and the driver's arrival at the hospital, the medical response team has to take the time to collect two blood samples in order to calculate the driver's blood alcohol content at the time of the accident. Investigators also need to take urine samples from drivers to screen for stimulants, synthetic cannabis, and other illegal drugs that impair driving performance. If these procedures gain traction and become an established part of protocol, it will be possible to deter driving under the influence of alcohol and drugs—two types of behavior that can cause fatal accidents.

4) A hit-and-run incident robs the victim of the opportunity for aid and places a heavy criminal burden on the perpetrator. To prevent hit-and-run incidents, we need to educate drivers about their obligations to aid victims and make a point of the high crime-arrest ratio for hit-and-run.

References


**Fig. 3.** Electropherograms of DNA typing of four loci of short tandem repeat. Green shows size markers, while red shows sample DNA.


