Chapter 12

Traffic Medicine

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1. Introduction

Driving a motor vehicle is a complex task requiring a reasonable level of physical fitness, accurate perception, and appropriate judgment. All these factors can be affected by drugs and alcohol, greatly increasing the risk of accidents. Many medical conditions (and their treatments) may impair fitness to drive and are considered first.

2. Medical Aspects of Fitness to Drive

Licensing requirements depend on the type of vehicle driven, with more stringent requirements for commercial purposes and multiaxle vehicles. In many jurisdictions, including Canada, Australia, and the United Kingdom, it is the motorist's responsibility to inform the licensing authority of any relevant medical conditions. Similar requirements generally apply in the United States, except that six states (California, Delaware, Nevada, New Jersey, Oregon, and Pennsylvania) require physicians to report patients with seizures (and other conditions that may alter levels of consciousness) to the department of motor vehicles *(1)*. Drivers have a legal responsibility to inform the licensing authority of any injury or medical condition that affects their driving ability, and physicians should take great pains to explain this obligation. Occasionally, especially when dealing with patients suffering from dementia, ethical responsibilities may require doctors to breach confidentiality and notify patients against their will or without their knowledge *(2)*; this situation is discussed in Subheading 2.5.

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Requirements vary in different countries and in different jurisdictions within the same country. When in doubt about the appropriate course of action, physicians should consult the appropriate guidelines. In the United Kingdom, the Driver and Vehicle Licensing Agency (DVLA) has made available the At-a-Glance Guide to the Current Medical Standards of Fitness to Drive *(3)*. In Australia, the Austroads Guidelines for Assessing Fitness to Drive provides similar information *(4)*. In the European Union, where European Community directives have developed basic standards but allow different countries to impose more stringent requirements, there is still variation from country to country. The situation is even more complicated in the United States, where each state sets its own rules and where federal regulations for commercial vehicles apply as well. Often, much of the required regulatory information can be acquired via the Internet or from organizations and foundations representing patients who have the particular disease in question.

It should be assumed that all adults drive; drivers with disabilities should be given special consideration and may require modification of their vehicle or have certain personal restrictions applied.

2.1. Cardiovascular Diseases

Several studies have demonstrated that natural deaths at the wheel are fairly uncommon and that the risk for other persons is not significant *(5,6)*. Even so, requirements for commercial drivers are generally much more rigid than for individuals, and in the United States, the Federal Highway Administration prohibits drivers with angina or recent infarction from driving. The length of prohibition varies from state to state. Restrictions for noncommercial car driving after first acute myocardial infarction are 4 weeks in United Kingdom but only 2 weeks in Australia. In the United States, they are entirely at the discretion of physicians. In general, ischemia itself is not considered an absolute disqualification, provided treadmill stress testing demonstrates that moderate reserves are present *(7)*. Similarly, individuals with controlled hypertension are usually considered fit to drive, although physicians, no matter what country they are in, must give serious thought to just what sort of medication is used to control hypertension; clonidine, methyldopa, reserpine, and prazosin can produce somnolence and/or impair reflex responses.

Patients with dysrhythmias treated with medication or with the implantation of a defibrillator/pacemaker present a special set of problems *(8)*. The tendency in the United States has been to treat such individuals as if they were epileptics (i.e., individuals with the potential to lose consciousness at the wheel). Most states set minimum requirements for seizure-free periods. Until recently, that period was 6 months in a majority of jurisdictions but is increasingly

being shortened to 3 months in many locations. In the United Kingdom, patients with implantable cardioverter defibrillators are permanently barred from holding a group 2 license but may hold a group 1 license, providing the device has been implanted for 6 months and has not administered therapy (shock and/or symptomatic antitachycardia pacing) *(3)*.

2.2. Epilepsy

Epilepsy is the most common cause of collapse at the wheel, accounting for approx 30% of such incidents. In the United Kingdom, epilepsy is a prescribed disability (along with severe mental impairment, sudden attacks of disabling giddiness, and inability to meet eyesight requirements), and car driving is not allowed for at least 1 yr after a seizure. Restrictions vary from country to country. All 50 of the United States restrict the licenses of individuals with epilepsy if their seizures are not well controlled by medication. Most states require a 6-months seizure-free period and a physician's statement confirming that the individual's seizures have, in fact, been controlled and that the individual in question poses no risk to public safety. The letter from the physician is then reviewed by a medical advisory board, which may or may not issue a license. In the United States, even if the patient, at some later date, does have a seizure and cause an accident, the physician's act of writing to the board protects him or her from liability under American law, provided the letter was written in good faith.

Withdrawal of antiepileptic medication is associated with a risk of seizure recurrence. One study showed that 41% of patients who stopped treatment slowly developed a recurrence of seizures within 2 years, compared with only 22% of patients who continued treatment *(9)*. The legal consequences of discontinuing medication without a physician's order can be devastating. Patients who stop taking antiseizure medication and then cause an accident may face future civil liability and possibly even criminal charges if they cause physical injury *(10)*. Of course, rules vary from country to country but, in general, a patient with seizures who does not inform the appropriate regulatory agency may face dire consequences (including the legitimate refusal of the insurance carrier to pay for damages).

2.3. Diabetes

Diabetes may affect the ability to drive because of loss of consciousness from hypoglycemic attacks or from complications of the disease itself (e.g., retinopathy causing visual problems or peripheral vascular disease causing limb disabilities). In January 1998, the British government introduced new restrictions on licensing of people with insulin-dependent diabetes *(11)*. These

restrictions were based on the second European Union driver-licensing directive (91/4389), and under most interpretations of the law, they prevent insulin-treated diabetics from driving light goods and small passenger-carrying vehicles. In response to concerns expressed by the diabetic community in Britain, the British Diabetic Association commissioned a report that found little evidence to support the new legislation. Regulations were therefore changed in April 2001 to allow "exceptional case" drivers to apply to retain their entitlement to drive class C1 vehicles (3500–7500 kg lorries) subject to annual medical examination.

In the United States, the situation varies from state to state, but in many states, individuals with diabetes are subject to restrictive licensing policies that bar them from driving certain types of motor vehicles *(12,13)*. However, the risk of hypoglycemia differs greatly among insulin-requiring diabetics, and today most insulin-dependent diabetics use self-monitoring devices to warn them when their blood glucose levels are becoming too low. Thus, several states have dropped blanket restrictions and allow for case-by-case evaluations to determine medical qualifications for diabetics. In some states, physicians are specifically required to notify authorities of the patient's diabetic conditions, but in all states, it is the patient's responsibility to do so. As with patients with seizure, failure to notify may expose the patient to both civil and criminal liability.

2.4. Vision and Eye Disorders

The two most important aspects of vision in relation to driving are visual acuity and visual fields. Visual acuity may simply be defined as the best obtainable vision with or without spectacles or contact lenses. Most countries require a binocular visual acuity greater than 6/12 for licensing purposes. In the United Kingdom, the eyesight requirements are to read a car number registration plate at 20.5 m, which corresponds to between 6/9 and 6/12 on the Snellen chart. The minimum field of vision for safe driving is generally regarded as at least 120° on the horizontal when measured with a Goldman IV4e target or its equivalent *(14)*.

2.5. Ethical Considerations

Although it is generally a patient's responsibility to inform the licensing authority of any injury or medical condition that affects his or her driving, occasionally ethical responsibilities may require a doctor to inform the licensing authorities of a particular problem. If a patient has a medical condition that renders him or her unfit to drive, the doctor should ensure that the patient understands that the condition may impair his or her ability to drive. If the

patient is incapable of understanding this advice (e.g., because of dementia), the doctor should inform the licensing authority immediately *(15)*.

If patients continue to drive when they are not fit to do so, the doctor should make every reasonable effort to persuade them to stop, which may include informing their next of kin. If this still does not persuade the patient to stop driving, the doctor should disclose relevant medical information immediately, in confidence, to the medical adviser of the licensing authority. Before disclosing this information, the doctor should inform the patient of the decision to do so, and once the licensing authority has been informed, the doctor should also write to the patient to confirm that disclosure has been made *(15)*.

3. Alcohol and Driving

3.1. Metabolism of Alcohol

Alcohol is absorbed through the stomach and duodenum. Absorption depends on many factors, including sex and weight of the individual, duration of drinking, nature of the drink, and presence of food in the stomach. Alcohol dehydrogenase in the gastric mucosa may contribute substantially to alcohol metabolism (gastric first-pass metabolism), but this effect is generally only evident with low doses and after eating. Studies of alcohol dehydrogenase activity in gastric biopsies of women suggest a significant decrease in activity in women compared with men, which could explain why women have higher peak blood alcohol levels and are more susceptible to liver damage after consumption of smaller quantities of alcohol when compared with men *(16)*. Further details of alcohol metabolism are given in Chapter 10.

Once absorbed, alcohol is eliminated at a fairly constant rate, with 90% being metabolized in the liver and the remainder excreted unchanged in urine, breath, and sweat. The rate of elimination in moderate drinkers may vary between 10 and 20 mg/100 mL blood/h, with a mean of 15 mg/100 mL blood/h. Chronic alcoholics undergoing detoxification have elimination rates of 19 mg/100 mL blood/h or even higher *(17)*. This increased rate of alcohol burnoff is believed to be a consequence of increased activity of hepatic microsomal enzymes (P450IIE).

3.2. Effects of Alcohol on Performance

Alcohol affects mood and behavior, causing euphoria (which is particularly significant in risk taking) but also depressing the central nervous system (CNS). Even at low doses, there is clear evidence that alcohol impairs performance, especially as the faculties that are most sensitive to alcohol are

those most important to driving, namely complex perceptual mechanisms and states of divided attention. In a review of more than 200 articles *(18)*, several behavioral aspects were examined, including reaction time, tracking, concentrated attention, divided attention, information processing, visual function, perception, psychomotor performance, and driver performance. Most of the studies showed impairment at 70 mg/100 mL of blood, but approx 20% showed impairment at concentrations between 10 and 40 mg/100 mL of blood.

The definitive study on the relationship between risk of accident and blood alcohol concentration is that conducted in the 1960s in Grand Rapids, Mich., by Borkenstein and Dale *(19)*; data were collected on 5895 drivers involved in accidents and on 7590 drivers not involved in accidents. Comparison of the two groups disclosed that an accident was statistically more likely at blood alcohol levels greater than 80 mg/100 mL of blood, with accidents occurring more frequently as follows:

Blood alcohol (mg/100 mL)	Accident occurrence
50–100	1.5 times as frequently
100–150	4 times as frequently
Over 150	18 times as frequently

Further analysis of the data by Allsop *(20)* quantified the risks for different ages and different drinking habits. On average, the risk doubles at 80 mg/100 mL, increasing sharply to a 10 times risk multiplier at 150 mg/100 mL and a 20 times risk multiplier at 200 mg/100 mL of blood. For inexperienced and infrequent drinkers, the sharp increase occurs at much lower levels, whereas for the more experienced drinking driver it may not occur until 100 mg/100 mL (Fig. 1).

Therefore, this research has encouraged some countries to have a lower blood alcohol level for legal driving; in Australia, Canada, and some states of the United States, different levels and rules are applied for younger and/or inexperienced drivers (*see* Subheading 3.3.). Further evidence of the relationship between crash risk and blood alcohol levels has been shown by Compton and colleagues *(21)*, who studied drivers in California and Florida. This recent research studying a total of 14,985 drivers was in agreement with previous studies in showing increasing relative risk as blood alcohol levels increase, with an accelerated rise at levels in excess of 100 mg/100 mL of blood. However, after adjustments for missing data (hit-and-run drivers, refusals, etc.), the result was an even more dramatic rise in risk, with the relative risk of crash involvement being significantly elevated at blood alcohol levels of 40 mg/100 mL.

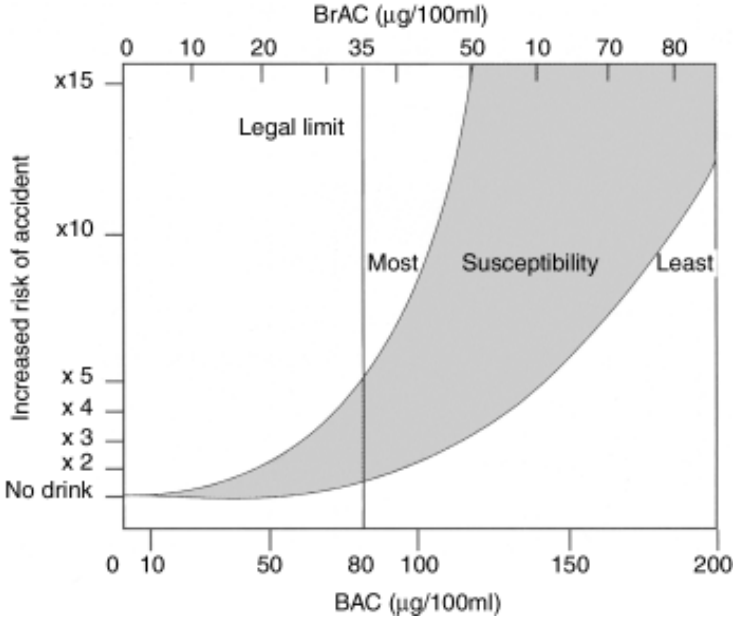

Fig. 1. Risk of road traffic accidents related to level of alcohol in the blood and breath. BAC, blood alcohol concentration; BrAC, breath alcohol concentration. Permission by Greenwich Medical Media.

3.3. Road Traffic Legislation

In the United Kingdom, this research led to the introduction of the Road Safety Act 1967, which set a legal driving limit of 80 mg/100 mL of blood (or 35 µg/100 mL of breath or 107 mg/100 mL of urine). This law also allows mandatory roadside screening tests and requires the provision of blood or urine tests at police stations. The Transport Act 1981 provided that quantitative breath tests, performed with approved devices, could be used as the sole evidence of drunk driving. Although the level for UK drivers is set at 80 mg/100 mL of blood, in practice, drivers are not usually prosecuted at blood levels below 87 mg/100 mL of blood because during the analysis, a series of results by gas chromatography, which must fall within 3 standard deviations (or 6%) of each other, is averaged, and then 6% (or 6 mg below 100 g/100 mL) is deducted from the result, which is then reported as not less than X mg/100 mL of blood.

In the United States, permissible blood levels vary from state to state and also by age. Many states have enacted "zero tolerance" laws, and the detection

of any alcohol in an individual younger than 21 years old is grounds for license revocation. Some states permit levels as high as 100 mg/100 mL, but most enforce the same limit as in the United Kingdom, and legislation to reduce the 80 mg/100 mL level further is under consideration. Repeated attempts to introduce one nationwide level have been rebuffed by the US Congress.

3.4. Equivalent Limits in Other Body Fluids

Statutes have been used to establish blood alcohol concentration equivalents in other tissues and breath. Not infrequently, alcohol concentrations will be measured in accident victims taken for treatment at trauma centers. However, there are two important differences between alcohol measurements made in hospitals and those made in forensic laboratories; first, in hospitals, standard international units are the norm, the mole is the unit of mass, the liter is the unit of volume, and alcohol concentrations are reported in mmol/L. In forensic laboratories, results are expressed as gram/deciliter or liter, or even milligrams per milliliter, and measurements are made in whole blood, not serum or plasma. Because 1 mL of whole blood weighs, on average, 1.055 g, a blood alcohol concentration of 100 mg/dL is actually the same as 95 mg/100 g or 21.7 mmol/L *(17)*.

There is another, even more important, difference between serum/plasma and whole blood. The former contains 91.8% water, whereas the latter contains only 80.1% water. Because alcohol has a large volume of distribution, this difference in water content means that alcohol concentrations measured in serum/plasma will be higher than concentrations measured in whole blood by approx 14%. In practice, if plasma alcohol concentrations are to be introduced as evidence, they should be related back to whole blood concentrations using an even higher ratio (1.22:1), which corresponds to the mean value, ± 2 standard deviations. As mentioned, if whole blood is tested, drivers are not usually prosecuted at blood levels below 87 mg/100 mL of blood *(17)*.

Breath testing is equally problematic. The instruments used are calibrated to estimate the concentrations of alcohol in whole blood, not plasma or serum. To estimate the serum or plasma alcohol concentration from breath measurements, a plasma/breath ratio of 2600:1 must be used (because, as explained, whole blood contains 14% less alcohol). In Europe, but not necessarily in the United States, two specimens of breath are taken for analysis, and the specimen with the lower proportion of alcohol should be used as evidence.

Bladder urine, because it contains alcohol (or other drugs) that may have accumulated over a long period, is generally not considered a suitable specimen for forensic testing, especially because the presence of alcohol in the

Table 1
Prescribed Blood Alcohol Levels in Various Jurisdictions

Australia	50	France	50	Poland	20
Austria	80	Germany	80	Romania	0
Belgium	80	Greece	50	Russia	0
Bulgaria	0	Hungary	0	Sweden	20
Canada	80	Italy	80	Spain	80
Czechoslovakia	80	Luxembourg	80	Turkey	0
Denmark	80	Netherlands	50	United States	100[a]
Ireland	80	Norway	50	Yugoslavia	50
Finland	50				

[a] Some states in the United States have reduced the legal level to 80 mg/100 mL of blood.

urine only proves that alcohol is present in the body. Alcohol concentrations in bladder urine cannot be used to infer the blood levels reliably. Even so, UK legislation and most US states still allow drivers the option of providing breath, blood, or urine specimens, but, as of 1999, the State of California has dropped the option of providing urine samples, and other states are considering similar actions. Under the new California provisions, police can still request a urine test if a suspect's breath test is negative *(22)*.

Other options are available in the case of alcohol-related fatalities. Comparison of alcohol concentrations in vitreous and blood can provide a good indication of whether concentrations were rising or falling at the time of death (alcohol is distributed mainly in water and the water content of vitreous is lower than that of blood). Urine obtained from the kidney pelvis can also be used, because its alcohol content can be precisely related to blood concentration *(23)*.

3.5. Legal Limits in Other Jurisdictions

Table 1 shows permissible alcohol limits for various countries. All figures are the maximum permissible amount in milligrams per 100 mL of blood (in the United States, referred to as deciliters [dL]). Although legislation has been introduced to enforce uniform standards, these standards have not been enacted, and in the United States, permissible alcohol levels vary from state to state.

3.6. Countermeasures

Numerous measures have already been taken to discourage drivers from drinking, and they have had a considerable degree of success.

3.6.1. Lowering the Legal Limit

When the legal limit was reduced in Sweden from 50 to 20 mg, there was a fall in casualties *(24)*. It has been estimated that a similar reduction in the United Kingdom would save 50 lives, prevent 250 serious injuries, and eliminate another 1200 slight injuries each year. A cost/benefit analysis suggests that this would save £75 million a year *(25)*. However, the UK government ultimately decided against reducing the legal limit.

3.6.2. Widening Police Breath-Testing Powers

Currently in the United Kingdom, a police officer may stop any person driving a motor vehicle on the road, but that does not necessarily mean that the officer can administer a breath test. As is the case in the United States, police officers can require a breath test only if there is reasonable cause to suspect that the person detained has alcohol in his or her body, has committed a moving traffic offense, or has been involved in an accident.

In Finland, random breath testing, along with a legal limit of 50 mg/100 mL of blood, was introduced in 1977; highly visible check points are established where typically 8–12 police officers with breath alcohol screening devices are placed along the center of the road, the sites being chosen so that it is impossible for a driver to avoid being tested. All drivers are tested, except those of emergency vehicles. The procedure takes only seconds to perform, the system receives general public support *(26)*, and it has resulted in a marked reduction in the number of accidents and injuries.

In the state of Victoria, Australia, "booze buses" are set up along with a roadblock—any driver who fails a roadside breath test is taken into the bus and given an evidentiary breath test (Drager 7100 machine). Every driver in Victoria is said to be tested on average at least once a year *(27)*.

3.6.3. Ignition Interlocks for Repeat Drunk-Driving Offenders

These devices prevent the car ignition from being started unless the concentration of breath alcohol blown into the device is below a predetermined level, often well below the legal limit. Thereafter, during the journey, the driver is required to undertake random rolling retests. A failure of these tests activates the vehicle's lights and horn. These devices have been used in several states of the United States and also in Alberta, Canada. They are generally applied to repeat offenders, either as an alternative to disqualification or in succession to a period of disqualification. Results in the United States have shown that repeat offenses occur rapidly once the restriction is removed *(28)*. However, in Alberta, where there is closer supervision of the

program, supplemented by counseling, more long-term improvements have been experienced.

3.6.4. High-Risk Offender Scheme

A special program in England, Wales, and Scotland was introduced in 1983, and the criteria widened in 1990 to cover drivers who were convicted of having a blood alcohol concentration (BAC) in excess of 200 mg/100 mL of blood, or refusing to provide an evidential specimen, or two offenses involving BACs in excess of 80 mg/100 mL of blood within a 10-yr period. This group accounts for approx 30–40% of drunk drivers in Britain. To regain their licenses at the end of a period of disqualification, the drivers must undergo a medical examination (including blood tests to discover biochemical evidence of excessive alcohol consumption) to demonstrate with reasonable certainty that they are not alcohol abusers *(3)*. Similar statues apply in the United States. In California, drivers with a BAC higher than 200 mg/100 mL, in addition to whatever other sanctions are imposed, are required to attend a 6-months educational program *(22)*. In the United States, penalties for drunk driving may be "enhanced" under special circumstances, such as a second conviction for drunk driving, speeding at the time of arrest, the presence of a child in the car, or the causation of property damage or injury.

3.7. Procedural Issues

Although the procedures involved may seem simple, numerous technical defenses have been raised in most countries throughout the world. Not surprisingly, many of these challenges are similar, no matter the country in which they are offered. Challenges to the UK Road Traffic Act are illustrative of the problem.

3.7.1. Definitions

Section 5(1) of the Road Traffic Act 1988 (RTA) states that if a person drives or attempts to drive a motor vehicle on a road or other public place, or is in charge of a motor vehicle on a road or other public place, after consuming so much alcohol that the proportion of it in his or her breath, blood, or urine exceeds the prescribed limit, he or she is guilty of an offense. Unfortunately, the word "drive" is not defined, but in fact, three points need to be proved: first, that the person is in the driving seat or has control of the steering; second, that the person charged must have something to do with the propulsion of the vehicle; and finally, that what the individual was doing must fall within the normal meaning of driving.

Attempting to drive has produced an abundance of case law, but it has been held that acts of mere preparation (e.g., checking the engine, finding keys, or opening the car door) do not amount to attempting to drive but steps on the way to what would have been driving, if not interrupted, may amount to an attempt (e.g., putting the key in the ignition). However, in a recent test case in the United Kingdom, when police found a man asleep in his van with the doors locked with a BAC over the legal limit, judges ruled by a majority decision that the laws that led to his conviction were disproportionate and violated the presumption of innocence to which he was entitled under Article 6(2) of the European Convention on Human Rights *(29)*.

In Section 185(1) of the RTA, a motor vehicle is defined as a "mechanically propelled vehicle intended or adapted for use on a road"—the words "mechanically propelled" are intended to have a wide meaning and will cover any transmission of power from the engine to the wheels by mechanical means. Similar regulations are to be found throughout the European Union, and if further evidence is needed regarding just how vague the definition of "mechanically propelled" may be, one needs only to consider the arrest in 1997 of a paraplegic Scandinavian who was arrested (and tried) for unsafe driving of his wheelchair.

In Section 192(1) of the RTA, the word "road" is defined as any highway and any other road to which the public has access and includes bridges over which a road passes. Public place is a question of fact for the court to determine. In English law, a car park attached to a public house was held, during opening hours, to be a public place because it was attached to a tavern that offered its services to all members of the public, whereas the same car park would not be regarded as a public place if it were attached to a private club *(30)*.

"In charge" is a question of fact, not law. As a general rule, the person remains in charge until he or she takes the vehicle off the road unless some intervening act occurs (e.g., handing keys to another person prevents him or her from retaining control). There is a statutory defense in that a person shall be deemed not to be in charge if he or she can prove that at the time, the circumstances were such that there was no likelihood of his or her driving the vehicle while the proportion of alcohol in the blood was over the prescribed limit. That the driver was injured or that the vehicle was damaged may be disregarded by the court if it is put forward as a defense. Therefore, the court is entitled to consider what the position would have been had the defendant not been prevented from driving by damage or injury. Of course, the state must always prove that the defendant was actually driving the car. That may prove difficult if, as is the case in many accidents, there are no witnesses.

3.7.2. Breath Testing

Section 6(1) of the RTA conferred the power to require a breath test only to officers in uniform. The courts have already ruled against a challenge where the officer was not wearing his helmet *(31)*. In the United Kingdom, the breath test may be taken either at or near the place where the officer makes a request for one. Normally, that would be at the roadside but not necessarily at the scene of the offense. If an accident occurs owing to the presence of a motor vehicle on a road or other public place, a police officer may require any person who he or she has reasonable cause to believe was driving or attempting to drive or in charge of the vehicle at the time of the accident to provide a specimen of breath for a breath test. The test may be taken at or near the place where the requirement was made or, if the police officer thinks fit, at a police station specified by the officer. In the United States, roadside breath testing, with nonevidentiary screening devices, is permitted only in "zero tolerance" states, with drivers under the age of 21 years.

In the United Kingdom, a person failing to provide a specimen of breath without reasonable excuse is guilty of an offense. A reasonable excuse would include someone who is physically or mentally unable to provide a sample, or if the act of providing the sample would, in some way entail risk to health. In most US states, refusal to submit to a breath (or blood or urine) test is admissible as evidence in criminal proceedings and, as a rule, leads to license suspension, even if guilt is not proved in court. In some states, refusal is actually considered a separate crime. This somewhat strange situation comes about because most US states and most other countries have *per se* laws for alcohol: an alcohol level above some preset limit is, by law, proof of intoxication *(32,33)*.

Section 6 of the RTA allows police officers to arrest a driver without a warrant if the breath test is positive or if the driver fails or refuses to provide a specimen of breath and the officer has reasonable cause to suspect alcohol in his or her body. Additionally, if an accident occurs owing to the presence of a motor vehicle on a road or public place and a police officer reasonably suspects that the accident involved injury to another person, then for the purpose of requiring a breath test or arresting a person, the officer may enter (by force if need be) any place where that person is or where the officer reasonably suspects the person to be.

3.7.3. Hospital Procedure

In the United Kingdom, patients at a hospital do not have to produce a breath test or provide a specimen for a laboratory testing unless the practitioner in immediate charge of their case has been notified and does not object on

the grounds that the requirement would be prejudicial to the proper care and treatment of the person. In the United States, forensic blood samples can be taken from unconscious patients who are not able to give informed consent. Recent legislative changes in the United Kingdom in the Police Reform Act 2002 give doctors similar powers with a few subtle differences in that blood can be taken providing the person has been involved in an accident, the doctor is satisfied that the person is not able to give valid consent (for whatever reason, which could include mental health problems) and the person does not object to or resist the specimen being taken *(34)*. After death, a coroner can order that the blood alcohol level be measured (remembering always that the value measured will be 14% lower than if serum or plasma had been measured at a clinical laboratory). In the United States, medical examiners and coroners do not require special permission to measure ethanol (or any drug for that matter), and they do so routinely. Ethanol concentrations in vitreous humor are made and may be introduced in court. However, no fixed relationship between postmortem blood and vitreous concentrations is recognized in law. Additionally, when bodily harm has resulted, or when there is evidence of criminal activity (such as leaving the scene of an accident), then it is within the power of the officer to order that blood be drawn, even if the suspect is unwilling or unconscious.

3.7.4. Police Station Procedure

Police may require a suspect to provide either two breath samples for analysis by means of an approved device or a sample of blood or urine for laboratory testing. This is usually done at a police station, because it is almost unheard of for a hospital in the United Kingdom or the United States to be equipped with an evidentiary breath testing device. Blood or urine samples can only be collected at a police station or hospital. In the United Kingdom, such a request cannot be made at a police station, unless the constable making the requirement has reasonable cause to believe that, for medical reasons, a specimen of breath cannot be provided, or at the time the requirement is made, an approved breath analysis device is not available, or not practical to use, or that the suspected offense is one under Section 3A or 4 of the RTA, and the constable making the requirement has been advised by a doctor that the condition of the person may result from some drug. This situation does not occur in the United States where, if appropriate staff are available, both blood and urine may be obtained at the police station.

In the United Kingdom, if a specimen other than breath is required, police may demand either a urine or blood test. If blood cannot be obtained as, for example, might well be the case in a chronic intravenous drug abuser, then a

urine sample must be provided within 1 hour of the request for its provision being made and after the provision of a previous specimen of urine. In the United States, urine specimens are generally not considered admissible proof of intoxication. A large number of studies have shown that the ratio between blood alcohol and pooled urine is highly unreliable and unpredictable *(35,36)*. Ureteral urine, on the other hand, has an alcohol concentration 1.3 times greater than blood *(23)*. Collection of ureteral urine is often attempted at autopsy, but for obvious reasons, is not an option with living patients.

Breath samples can only be analyzed with approved devices. Those currently in use include the Intoximeter EC/IR, Camic Datamaster, Lion Intoxilyzer 6000, and Drager Alcotest 7100 (Australia). Only officers who are trained to use the machine are allowed to conduct the intoximeter procedure, and the lower of two readings is taken. The subject must not have smoked for 10 minutes or have consumed alcohol or used a mouth spray or mouthwash, taken any medication, or consumed any food for 20 minutes before the breath test.

If the reading is below the prescribed limit of 35 μg of alcohol per 100 mL of breath, no action is taken unless impairment through drugs is suspected. If that is the case, a forensic physician should be called. If the level is between 36 and 39, no prosecution can occur unless there is impairment. If the level is between 40 and 50, the person is given the option of having the breath sample reading replaced by a specimen of blood or urine, but it is for the police officer to decide which, in accordance with Section 7. At levels over 51, the person is charged with an offense. Different rules and regulations, but with much the same intent, apply in other countries.

3.7.5. Blood Samples

It is wise to have a standardized routine for this procedure, if only to help prevent some of the technical defenses that are frequently raised in court. RTA blood alcohol kits are available with all the necessary equipment, and similar kits are sold in the United States, although their use is not mandatory. Regardless of whether or not a kit is used, appropriate chain of custody forms must be completed, and the record must reflect that alcohol-containing swabs were not used to cleanse the skin (actually, studies have shown that alcohol swabs contribute negligibly to the final result, but the issue is routinely raised in court) *(37)*.

The police officer should identify the doctor to the person, and the doctor should obtain witnessed informed consent. The physician must then determine whether there are any medical reasons why a sample of blood cannot be taken. It is for the doctor to decide from where the sample of blood is taken. The sample should be divided equally between the two bottles and shaken to dis-

perse the preservative (an additional needle through the rubber membrane helps to equalize the pressure). The bottles should be labeled and placed in the secure containers and caps applied. The driver is allowed to retain one sample, which is placed in an envelope and sealed. The driver is then given a list of analysts.

Under US law, blood may be taken even if the driver objects, providing the driver has been involved in an accident leading to injury or a crime has been committed. Most US states have statutes that excuse individuals with hemophilia and patients taking anticoagulants from blood testing *(22)*. Under British law, a forensic physician may make up to three unsuccessful attempts at taking blood before the driver can reasonably refuse to give blood on grounds that the defendant has lost confidence in the doctor. No such protection exists in US law.

3.7.6. Section 4, RTA

The medical examination and procedure to be adopted when it is suspected that a person is unfit through drink or drugs will be discussed later in Heading 4., Drugs and Driving.

3.8. Complex Defenses

Numerous technical defenses have been advocated over the years, and doctors should be aware of the most common. Failure to provide a sample of breath or blood will be considered separately.

3.8.1. Failure to Provide a Sample of Breath

Unless there is a reasonable excuse, failure to provide a specimen of breath, blood, or urine is an offense under Section 7 of the RTA. In the United States, refusal leads to automatic license suspension and, in some states, may actually constitute a separate crime; police are under an obligation to ensure that drivers are made aware of that. The motorist must understand the mandatory warning of prosecution if a specimen is not produced. Failure to understand, at least in the United Kingdom, is a reasonable excuse for the nonprovision of a sample *(38)*. The decision regarding whether there is a medical reason not to supply a sample of breath is left to the police officer and is summarized in case law. There is no provision or requirement at that stage for a doctor to be summoned or to give an opinion.

Examples of medically acceptable reasons include mouth, lip, or facial injury; tracheotomy; rib injury; and neurological problems. Case law has stated that fear of acquired immune deficiency syndrome (AIDS) not amounting to phobia *(39)*, shock *(40)*, and even intoxication *(41)* can, in certain circumstances, be regarded as reasonable excuses.

Many cases have been challenged on the basis that the person was unable to blow into the intoximeter because of respiratory problems. Research has now clarified some of these situations. Spirometry has shown that if a person has a forced expiratory volume in 1 s (FEV1) of less than 2 L and a forced vital capacity (FVC) of less than 2.6 L, then that person would generally be unable to use a breath alcohol testing device *(42)*. A further study of healthy people of small stature (less than 166 cm tall) showed that if their FEV1, FVC, and peak expiratory flow rate were greater than 2.31, 2.61, and 330 L/min, respectively, then they should be capable of supplying a suitable breath sample *(43)*. This article was particularly useful because most forensic physicians do not have access to spirometry but do have access to a simple peak flow reading in the custody situation.

A study in Victoria, Australia, showed that persons with an FEV1 greater than 1.51 could provide an adequate screening sample on the Lion Alcolmeter SD2 roadside screening device *(44)* and that with an FEV1 greater than 1.0 and FVC greater than 1.75, individuals were able to provide adequate samples on the Drager Alcotest 7110 (as used in Victoria) evidentiary breath testing machine.

A more recent study *(45)* on the new Lion Intoxilyzer 6000 concluded that some subjects with lung diseases may have difficulty in providing evidential breath samples. However, these were subjects who would generally have been considered to have severe lung diseases.

A recent fashionable defense is that the presence of a metal stud through a hole pierced in the tongue invalidates the breath alcohol test because of the prohibition against foreign substances in the mouth and because of the potential for the jewelery to retain alcohol and interfere with the breath test. However, experimental work has shown that the rates of elimination of mouth alcohol were no different in subjects with a tongue stud as opposed to controls and that for the purposes of breath alcohol testing, oral jewelery should be treated the same as metallic dental work and left in place without affecting the outcome of the breath test *(46)*.

3.8.2. Failure to Provide a Sample of Blood

First, there must be a definite request to provide a sample of blood. In *Kuldip Singh Gill v DPP (47)*, it was held that a driver could not be convicted of failing to supply a specimen of blood or urine if he or she was not requested to do so. Where the sample of blood is taken from is solely the choice of the forensic physician (or, in the United States, the emergency room physician). In *Solesbury v Pugh (48)*, the defendant was found guilty of failing to supply a specimen as he would only allow a sample to be taken from his big toe, which the doctor was not prepared to do.

It is reasonable for the person to request that his or her own doctor take the sample of blood, providing this does not delay the sample being taken *(49)*. In the United Kingdom, if the patient's own doctor and forensic physician are both present, the person can choose which doctor takes the sample. Similar rules apply in the United States, where statutes generally spell out that financial responsibility for such services rests with the driver and not the state. In the United Kingdom, if a blood sample is provided but the doctor spills the sample, then the law has been complied with on the basis that removal of the syringe from the vein by the doctor completes the provision of the specimen by the defendant *(50)*. In the United Kingdom, a minimum of 2 mL of blood is required (the laboratory requires a minimum of 1 mL for analysis) for an adequate sample *(51)*. If less than this is obtained, the sample should be discarded and another one attempted or the police officer advised that there is a medical reason why a sample of blood should not be provided and the urine option can then be selected. In the United States, minimum quantities are generally not written into statute. As indicated, alcohol swabs should not be used. In the early 1980s, one police force purchased and used swabs containing alcohol with the result that numerous convictions were later overturned *(52)*.

Probably the most common defense for failure to provide a sample of blood is that of needle phobia. If this is alleged, a full medical history should be obtained and enquiry made of whether the person has had blood tests before, whether ears or other parts of the body have been pierced, or whether there have been foreign travel immunizations or any other medical or dental procedure undertaken in which an injection may have been administered. Specific inquiry about the phobia should be made. British appellate judges *(53)* have stated that "no fear short of phobia recognized by medical science to be as strong and as inhibiting as, for instance, claustrophobia can be allowed to excuse failure to provide a specimen for a laboratory test, and in most if not all cases where the fear of providing it is claimed to be invincible, the claim will have to be supported by medical evidence." Stark and Brener *(54)* stress the importance of having a standardized approach for assessing needle phobia using diagnostic guidelines for a definite diagnosis of a specific phobia and wisely conclude that the best way to ensure a successful prosecution is to obtain a sample, any sample, for analysis. Rix also gives some practical advice to police surgeons: be able to distinguish between repugnance and phobia, be able to distinguish between unwillingness and inability, document the history and examination with emphasis on the presence or absence of signs of anxiety, and ensure that the decision is based on firm medical evidence. Finally, record all this information, specifically note in the police record

whether a medical condition has been identified, and then verbally communicate this opinion to the police officers *(55)*.

Another common defense is that of consuming alcohol after the offense–the hip flask defense *(56)*. It is used almost universally and is based on the fact that although it is unlawful to have an excessive BAC at the time of driving, it is not unlawful to have an elevated blood alcohol at the time of being tested. In the United Kingdom, Section 15(3) of the RTA allows for a driver to prove that he or she had imbibed alcohol after ceasing to drive and that the amount of such consumption was the sole reason for being over the legal limit or unfit to drive, at the time he or she gave a sample for analysis. It will be necessary for a scientist to prove that it was only the postdriving consumption that caused the analysis to reveal an alcohol level above the prescribed limit. The quantity of alcohol in the after-drink, the time of intake, and the age, sex, height, and body weight of the driver can all be used to calculate the theoretical expected BAC *(57)*. Back calculations can only be approximate because they are based on average values, and although they are reasonable estimates for most people, they may occasionally fail to reflect accurately the situation of a particular individual, regardless of whether the calculation is for preincident or postincident drinking.

3.8.3. Failure to Provide a Urine Sample

If a woman is requested to provide a urine sample, it is important to have a female officer present because it has been held that because of the embarrassment that it could involve, the refusal to supply a sample of urine could be regarded as a reasonable excuse *(58)*. However, any embarrassment at having to urinate in front of an officer of the same sex is not regarded as a reasonable excuse for not having supplied a specimen. Similar statutes apply in the United States. Methadone and other opiates have an effect on the bladder sphincter and can thus cause delayed bladder emptying; this effect could be considered a reasonable excuse for failing to provide a urine sample *(59)*. In Sweden, Jones *(56)* reported the top 10 defense challenges for driving under the influence of alcohol (Table 2). This situation may be subject to some change, because medications, such as tolterodine (Detrusitol) and other muscarinic receptor antagonists, are being increasingly prescribed for treatment of patients with symptoms of an unstable bladder. This may explain why California has already dropped urine from its list of testing options.

3.9. Postmortem Alcohol Measurements

This topic has recently been reviewed in depth by Pounder and Jones *(23)*. High postmortem alcohol concentrations do not imply that impairment

Table 2
Top 10 Defense Challenges For Driving Under the Influence of Alcohol

1. Drinking after the offense—the hip flask defense.
2. Laced drinks.
3. Inhalation of ethanol vapors from the work environment.
4. Pathological condition or trauma.
5. Use of skin antiseptics containing ethanol.
6. Alleged mix-up of blood specimens.
7. Postsampling formation of alcohols.
8. Drug–alcohol interactions.
9. Consumption of elixirs or health tonics containing alcohol.
10. Infusion of blood or other liquids during surgical emergency treatment.

was evident during life. Of 32 alcoholics presented at an emergency room for medical treatment, only 23 had apparent behavioral abnormalities, six were confused, and three were drowsy, even though the mean alcohol concentration was 313 mg/100 mL (range 180–450 mg/100 mL) *(60)*. Alcohol can be measured in numerous tissues, but the most accurate picture is usually obtained when multiple sites are sampled (e.g., vitreous, gastric contents, blood, and urine) particularly if ureteral urine is available and the alcohol concentrations compared.

Because the eye is anatomically isolated, putrefaction is delayed, and there is little problem with postmortem redistribution, vitreous measurements can be used to confirm values obtained from whole blood and urine, to distinguish postmortem alcohol production from antemortem ingestion, and to determine whether blood alcohol concentrations were rising or falling at the time of death. Vitreous contains more water than blood so that the blood/vitreous alcohol ratio is less than 1. Ratios greater than 1 suggest that death occurred before equilibrium had been reached (i.e., blood alcohol was still rising) *(61)*. Vitreous alcohol concentrations can be related to blood concentrations; however, there is so much intraindividual variation that extrapolation in an individual case is probably unwise and unsound scientifically.

As mentioned, serum and plasma contain more water than whole blood, and it follows that the alcohol content of the former will be 10–15% higher than the latter. Because postmortem measurements are made with whole blood and the water content of the cadaver begins to decrease almost immediately after death, estimating antemortem values with any precision is difficult, especially if only blood has been sampled. However, if samples from multiple sites are obtained, and vitreous, blood, and urine (urine as it is being formed contains 1.3 times as much alcohol as whole blood) are all analyzed,

it may be possible to make a reasonable estimate of what the alcohol concentration was at the time of death *(23)*.

4. Drugs and Driving

4.1. The Problem

Increasing alcohol levels are associated with increased risk of accidents, but fatigue, drug abuse, and even the use of prescription medication can also increase risk *(62)*. The danger associated with sedatives and hypnotics is readily appreciated, but other drugs, such as anticholinergics, antidepressants, antihistamines, and antihypertensive medications, may occasionally cause drowsiness. Patients should be warned about this, and after starting therapy or after a significant change in dose, they should avoid driving until it is known that unwanted effects do not occur *(63,64)*.

4.2. The Scale of the Problem

The size of the problem is not really known. In the United Kingdom in 1997, more than 860,000 breath tests for alcohol were conducted, with a refusal (presumed positive) rate of 12% (103,000) (D. Rowe, DETR, personal communication, 1999). During the same period, the Forensic Science Service (FSS) dealt with only 1850 drugs/driving submissions. In a 2-weeks period in August 1996, the FSS received 270 blood specimens for testing for driving with excess alcohol. Further examination revealed that 18% contained one or more drugs, and of those that fell below the legal alcohol limit, a further 18% were positive for drugs. If this 18% figure were applied to those 103,000 cases in 1997, more than 18,000 cases would have been identified in which drivers had drugs in their body *(65)*.

In October 1999, the UK Department of Environment, Transport and the Regions completed a 3-years study into the incidence of drugs in road accident fatalities *(66)*. There were a total of 1138 road user fatalities, including drivers, riders of two-wheeled vehicles (34 of them cyclists), passengers in vehicles, and pedestrians; more than 6% tested positive for medicinal drugs, 18% for illicit drugs (mainly cannabis), and 12% for alcohol.

In this study, urine was tested by immunoassay for the following drugs: alcohol, amphetamines, methyl amphetamines (including ecstasy), cannabis, cocaine, opiates, methadone, lysergic acid diethylamide, benzodiazepines, and tricyclic antidepressants. The incidence of medicinal drugs likely to affect driving had not significantly changed from the 1985–1987 study *(67)*. However, illicit drug taking in drivers had increased sixfold in percentage terms, and there was a comparable increase among passengers. In addition, an in-

Table 3
Type of Drug Detected in Samples Submitted to the FSS in 1997

Amphetamine	13%	Methylamphetamine	3%
Cannabis	28%	Cocaine	6%
Opiates	16%	Methadone	7%
Benzodiazepines	24%	Others	3%

creasing number had taken more than one illicit drug. In 1997, drugs were detected in approx 90% of samples submitted to the UK FSS for analysis (Table 3).

4.3. Effects of Different Drugs

The effects on driving of different drugs are now considered.

4.3.1. Cannabis

Numerous studies have been undertaken to examine the effects of cannabis on driving. One large meta-analysis of more than 150 studies showed that cannabis impairs the skills important for driving, including tracking, psychomotor skills, reaction time, and performance, with the effects most marked in the first 2 h after smoking and with attention, tracking, and psychomotor skills being affected the most *(68)*. The study also showed that impairment is most marked in the absorption phase as opposed to the elimination phase and that frequent cannabis users become less impaired than infrequent users. These are, for the most part, older studies, done during the 1970s. Impairment is dosage dependent, and externally observable symptoms (e.g., impairment of psychomotor skills or the impression of absent-mindedness), disappear quickly during the early elimination phase. More recent studies *(69)* conducted with volunteer marijuana smokers who were actually driving found that the main effect of marijuana was to increase lateral movement of the vehicle moderately within the driving lane on a highway *(70,71)*. A UK study *(72)* offered further support for the view that when under the influence of cannabis, users are acutely aware of their impairment but attempted to compensate for their impairment by driving more cautiously.

4.3.2. Opiates

Single doses of narcotics can have marked effects on performance, such as reaction time. However, most studies of opiates among regular users suggest that they do not present a hazard or exist as a significant factor in driving.

One study compared the effects of alcohol, diazepam, and methadone on clients commencing or stabilized on a methadone program. The battery of tests showed no evidence for an effect of the acute dose of methadone; thus, clients on a methadone program should not be considered impaired in their ability to perform complex tasks, such as driving a motor vehicle. Thus, in the United Kingdom, persons on a stable methadone program who have not abused other drugs for 1 yr and who have clear urine drug screening tests regularly are allowed a driving license subject to annual review. However, it should be remembered that users of heroin are also prone to heavy use of other psychoactive drugs, such as cocaine, alcohol, and tranquilizers, which are all dangerous when it comes to driving.

This problem is illustrated by a more recent study from Germany *(73)*. Thirty-four methadone substitution patients, all of them volunteers, were subjected to a battery of psychological tests. Twenty-one of these patients had to be excluded from the study because the toxicological analysis of repeated blood and urine samples revealed the presence (or possibly chronic use) of substances other than methadone. Of the remaining 13 (age range 26 to 42 years, 8 males and 5 females) 6 were selected who, based on the impression of the physicians, could be described as optimal methadone patients. Although some personality scales and psychopathological findings revealed shortcomings for a few of these patients, they could not be regarded as factors ruling out driver fitness, and the authors concluded that under certain conditions, long-term methadone maintenance patients under strict medical supervision do not suffer significant driving impairment, providing that no other drugs have been taken.

4.3.3. Cocaine and Methamphetamine

Although the argument often goes unchallenged in court, all drugs do not, by definition, produce impairment. Even though some US states define "being under the influence" as synonymous with the presence of any drug, some drugs do improve performance. In fact, low to moderate acute doses of cocaine and amphetamine can be expected to increase positive mood, energy, and alertness, especially in nontolerant individuals *(74)*. It has been known since World War II that use of D-amphetamine can increase the ability to sustain attention for prolonged periods when performing monotonous tasks. For that reason, radar operators and pilots of both Allied and Japanese armies were issued supplies of amphetamine. Many of the performance tasks related to driving can be improved, at least in the laboratory, by treatment with stimulants *(75)*. Although the results of one retrospective autopsy study suggest that methamphetamine users seem more likely to be involved in traffic accidents *(76)*, a driving simulator study *(77)* of young people who had taken

ecstasy (3,4-methylenedioxymethamphetamine) showed that basic vehicle control is only moderately affected but risk taking is increased. It seems likely that abrupt discontinuation of either drug in a chronic user could result in driving impairment, but that situation has never been tested *(70)*. Large doses can result in toxic psychosis with symptoms indistinguishable from paranoid schizophrenia, a condition that is extremely unlikely to improve driving performance.

4.3.4. Sedative Hypnotics

Benzodiazepines impair psychomotor performance in nontolerant individuals, generally in a dose-dependent manner. Most of the widely prescribed benzodiazepines increase lateral lane movement and slow response time to a lead car's change in speed. Several of the benzodiazepines (50 mg of oxazepam, 30 mg of flurazepam, and 2 mg of lormetazepam) predictably impair driving the morning after. Diazepam (15 mg) impaired performance on a clinical test for drunkenness, which comprised 13 tests assessing motor, vestibular, mental, and behavioral functioning *(78,79)*. A recent study *(80)* showed a clear relationship between dose of benzodiazepines and risk of impairment, which the authors believed probably supported a limit for benzodiazepines and driving as low as within the therapeutic range.

Acute doses of many benzodiazepines slow response time in simple or choice visual reaction time tests and impair attentional performance and cause deficits that do not result from sedation. In fact, the impairment of sustained attention and vigilance in benzodiazepine users is the direct result of some as yet uncharacterized direct action on perceptual sensitivity *(70)*.

4.3.5. Multiple Drug Use

Polydrug use is common and can result in complex interactions, with the drugs having additive, antagonistic, or overlapping effects. Alcohol is commonly consumed in addition to abused drugs. In a study on alcohol and cannabis *(81)*, it has been shown that when they are administered together, the result was one of additive impairment. This finding was confirmed in a recent UK study *(82)*. However, in the laboratory setting, simultaneous administration of alcohol and cocaine seems to minimize alcohol-related deficits *(75)*.

4.3.6. Antidepressants

There are many side effects associated with the use of the tricyclic antidepressants (TCAs) (e.g., amitriptyline), that are relevant to the ability to drive, such as blurred vision, slow visual accommodation, disorientation, and eye–hand coordination; the most important are the induction of drowsiness,

lethargy, and sedation. An analysis of 500 road traffic accidents showed that victims who had taken TCAs had a relative accident risk 2.2 times greater than non-TCA users and that patients using TCAs with a daily dose greater than or equivalent to 125 mg of amitriptyline had a sixfold increase in road traffic crash risk *(83)*. The newer antidepressant drugs of the serotonin reuptake inhibitor class (e.g., fluoxetine, paroxetine, or the selective serotonin and noradrenaline re-uptake inhibitors [venlafaxine]) do not generally affect driving performance and are safe for use by patients who drive *(84)*.

4.3.7. Over-the-Counter Preparations

An increasing number of drugs can now be bought over the counter from pharmacies. Many of these preparations (e.g., cough mixtures and decongestants), contain drugs that can cause sedation, particularly the older antihistamines (e.g., chlorpheniramine). The newer nonsedating antihistamines, such as terfenadine and astemizole, generally do not impair driving. However, one study that measured driving performance across differing doses of terfenadine found that performance was impaired at very high doses (240 mg), stressing the need to establish the behavioral effects of drugs over a range of doses *(85)*. The second-generation group of antihistamines is less lipophilic than the previous generation and thus cross the blood–brain barrier less readily, which accounts for the lower levels of sedation observed with the newer drugs. Thus, although the second-generation antihistamines generally produce less sedation than first-generation compounds, if therapeutic doses are exceeded, the so-called nonsedating antihistamines become sedating and can impair driving.

4.4. Assessment in the Field by Police

In the United Kingdom, if a police officer stops a driver, for whatever reason, and believes the driver is unfit to drive, it is highly likely that a roadside breath test will be conducted. That is not the case in the United States, where field breath testing is only permitted in some states, and then only for drivers under the age of 21 years *(22)*. The laws of the United States also prevent random breath testing. Under the Fourth Amendment, searches and seizures must be reasonable. Stopping a vehicle is a seizure, but it may be reasonable if the police officer has a justifiable suspicion that an offense is being committed. The procedures American officers follow in driving under the influence cases are surprisingly similar to the procedures under the United Kingdom Section 4 RTA. To gain powers to conduct further tests, officers in most US states first have to be satisfied that the driver is impaired. This then gives them the probable cause to carry out subsequent tests similar to the Section 4 procedure to prove impairment.

If breath testing is negative, impairment resulting from drugs or medical illness must be considered. Until recently in the United Kingdom, police traffic officers received little or no training in the recognition of signs and symptoms of drug effects. However, a pilot study *(86)* was carried out in England, Wales, and Scotland in 1999, whereby police officers were trained to perform roadside impairment tests; this study showed that forensic analysis confirmed the presence of a drug in 92% of the drivers who were suspected of taking a drug, who had failed the field impairment tests (FIT) and who had provided a sample. As a consequence, FIT is now slowly being introduced across the United Kingdom. This contrasts dramatically with the United States, where in 1979, the Drug Recognition Expert (DRE) Program was introduced. Police officers were trained to observe and document known indicators of drug use and impairment.

Instead of breath testing, a series of standardized field sobriety tests, which include psychomotor and divided attention tests, is conducted. If alcohol is suspected, the following tests are carried out: walk and turn test, one-leg stand, and the horizontal gaze nystagmus test. In addition, if drugs are suspected, a Romberg balance test is also carried out. Unlike chemical tests (with refusal to submit possibly resulting in immediate license suspension), drivers in the United States are not legally required to take any field sobriety tests; however, if the driver submits, the results can be introduced as additional evidence of impairment.

These tests are all divided attention tests, which assess the individual's balance and coordination, as well as the ability to follow simple instructions (i.e., to divide attention between multiple tasks). They are as follows:

- Horizontal gaze nystagmus: nystagmus may be caused by any number of conditions, but its presence could indicate drugs or alcohol.
- Walk and turn: nine steps heel to toe are taken in one direction, and then the individual turns and repeats the process in the other direction. Eight impairment indicators are measured; if two of the eight are present, impairment would be indicated.
- One-leg stand: the subject has to stand on alternate feet for 30 s while counting aloud. Failing two of the four recognized indicators would indicate impairment.
- Romberg balance test: the subject stands with eyes closed and estimates a period of 30 s during which body sway is estimated. Some drugs alter the body's internal clock and make the person act faster or slower than normal. The test allows for a tolerance of ±10 s.

If impairment is identified and alcohol is suspected, the driver performs a breathalyzer test and a similar procedure to the United Kingdom Section 5 RTA procedure is conducted. However, if drugs are suspected, the police officer would call on a DRE to carry out a more detailed examination.

The DRE will use a 12-step procedure as follows:

1. Breath alcohol test: this is carried out by the arresting officer; if the reading is not consistent with the degree of impairment, the DRE is called in.
2. Interview with the arresting officer: the purpose is to ascertain baseline information, including the circumstances of the arrest, whether an accident occurred, whether drugs were found, and if so, what they looked like.
3. Preliminary examination: the purpose of the preliminary examination is to determine whether if there is sufficient reason to suspect a drug offense and to try to exclude any underlying medical problems. General observations and details of any current medical problems are ascertained, and the first measurement of the pulse is taken. If no signs of drug influence are found, the procedure is terminated; if any medical problems are found, a medical assessment is obtained, and if drugs are still suspected, a full assessment is carried out. If at any time during the assessment a serious medical condition is suspected, a medical opinion will be obtained.
4. Eye examination: the driver is assessed for horizontal gaze nystagmus, vertical gaze nystagmus, and convergence.
5. Divided attention tests: once at a police station, the Romberg balance test, walk and turn test, one-leg stand test, and the finger-to-nose test are carried out. These are all examples of divided attention tests whereby balance and movement tests are performed in addition to remembering instructions.
6. Vital signs examination: blood pressure, temperature, and a second recording of the pulse are carried out.
7. Darkroom examination: pupil size is measured in room light and then in near total darkness, using both indirect artificial light and direct light. The mouth and nose are also examined for evidence of drug use.
8. Muscle tone: limb tone is assessed as some drugs cause rigidity, whereas others, for example, alcohol, cause flaccidity.
9. Injection sites examination: the purpose is to seek evidence of intravenous or injection drug abuse. A third pulse reading is taken.
10. Interrogation: a structured interview about the use of drugs is carried out.
11. Opinion: based on all the previous assessments, the DRE forms an opinion as to drug impairment and also the type of drug causing the problem, the legal standard being a reasonable degree of certainty.
12. Toxicology testing: at the same time, samples are obtained for toxicological examination, either a blood or urine sample being taken for analysis of common drugs.

Initial studies, suggesting high sensitivity and specificity for DRE examination *(87)*, have not been confirmed in controlled laboratory studies. The results of the few studies that have been performed suggest that the accuracy of DRE assessment in general may not be sufficiently good to provide evidence in court fairly *(70,71)*. Several field studies have indicated that a DRE's opinions were confirmed by toxicological analysis in 74–92% of cases when DREs concluded that suspects were impaired. However, published controlled trials,

in which blood levels were measured before and during DRE examination, have shown that except in the case of alcohol, DRE assessment agreed with toxicology findings only 32–44% of the time.

There are other options for roadside screening tests. Both sweat and saliva have been used *(88)*. Devices are already available, and some have been approved by the US Department of Transportation for the testing of commercial drivers. The mere detection of a drug does not prove impairment unless, of course, the jurisdiction has *per se* laws whereby the detection of drugs at some predetermined level is ruled, by law, to be proof of impairment. Roadside drug screening tests are acceptable to the public; a UK study *(89)* found that 98% of drivers were in favor of the principle of road side drug screening and found the test methods of saliva or forehead perspiration generally acceptable. The UK Home Office Police Scientific Development Branch are currently researching the use of computer program for detecting impairment and Surface Enhanced Raman Spectroscopy as a means of quantitative analysis of saliva for drugs.

4.5. Medical Examination Under Section 4 of the RTA

In the United Kingdom, it is not necessary to prove impairment, as Section 7(3)(c) of the RTA states that: "the suspected offence is one under Section 3A or 4 of this Act and the constable has been advised by a medical practitioner that the condition of the person required to provide the specimen *might* [author's emphasis] be due to some drug." It is for the court to decide whether the driver is unfit to drive on the evidence before it.

Whether the examination is carried out by a forensic physician in London or an emergency room physician in San Francisco, the aim of the examination is to exclude any medical condition other than alcohol or drugs as the cause of the driver's behavior. The differential diagnosis is wide and includes head injury, neurological problems (e.g., epilepsy, stroke, cerebral tumour, and multiple sclerosis), metabolic problems (e.g., hypoglycemia), hepatic or renal failure, and mental illness. The procedure should include introductory details, full medical history, and clinical examination. In Scotland, forensic physicians use form F97. Appendix 6 contains a form that has been found useful. Similar forms are not available in the United States, but there is nothing to prevent any emergency department in the United States from drafting and providing a similar document. Even if no special form is provided, most of the relevant material will have been (or at least should be) recorded in the emergency department record.

4.5.1. Introductory Details

These should include the name, address, and date of birth of the driver and the name and number of the police officer, as well as the place and date

the examination took place, and various times, including time doctor contacted, time of arrival at police station/hospital, and time the examination commenced and ended.

The doctor will need to know brief details of the circumstances leading to arrest and the results of any field impairment tests that may have been carried out by the police officer. Informed consent should be obtained.

4.5.2. Full Medical History

Details of any current medical problems and details of recent events, particularly whether there was a road traffic accident that led to the event, should be recorded. Past medical history (with specific reference to diabetes, epilepsy, asthma, and visual and hearing problems), past psychiatric history, and alcohol and drug consumption (prescribed, over the counter, and illicit) should be noted.

4.5.3. Clinical Examination

This should include general observations on demeanor and behavior, a note of any injuries, speech, condition of the mouth, hiccoughs, and any smell on the breath. The cardiovascular system should be examined and pulse, blood pressure, and temperature recorded. Signs of drug abuse should be looked for (e.g., needle marks). Examination of the eyes should include state of the sclera, state of the pupils (including size, reaction to light, convergence, and the presence of both horizontal or vertical nystagmus).

A series of divided attention tests should be performed including the Romberg test, finger–nose test, one-leg-stand test, and walk and turn test. A survey of forensic physicians' opinions within Strathclyde police demonstrated concerns regarding the introduction of standardized field sobriety tests with the walk and turn test and the one-leg-stand test, causing the highest levels of concern *(90)*. The mental state should be assessed and consideration given to obtaining a sample of handwriting. Fitness for detention is of paramount importance, and any person who is not fit to be detained because of illness or injury should be transferred to hospital and not subjected to a Section 4 assessment. If the person refuses to consent to an examination, it is prudent to make observations on his or her manner, possible unsteadiness, etc. and make written note of these.

At the end of the examination, the doctor should decide whether there is a condition present that may result from some drug. In the case of short-acting drugs, the observations of the police officer or other witnesses can be of crucial importance. In a recent case, a person was found guilty of driving while unfit resulting from drug use on the basis of the officer's observations and the results and opinion of the toxicologist; the forensic physician was not called to give evidence *(91)*. Similarly, if the police officer reports that the person

was swerving all over the road but the doctor later finds only minimal physical signs, this may be sufficient to indicate that a condition may be present because of some drug (e.g., cannabis) and that it is appropriate to proceed to the next part of the procedure.

The doctor should inform the police officer whether there is a condition present that may be the result of a drug, and if so, the police officer will then continue with the blood/urine option. Consent will need to be obtained for a blood specimen. On this occasion, 10 mL of blood should be taken and divided equally into two septum-capped vials because the laboratory requires a greater volume of blood for analysis because of the large number of drugs potentially affecting driving performance and their limited concentration in body fluids; indeed, if the driver declines the offer of a specimen, both samples should be sent.

As a means of further validating FIT as an effective means of detecting drivers who are impaired because of drugs, the University of Glasgow is carrying out further research *(92)*. Those drivers stopped under suspicion of impairment who are under the legal alcohol limit but still considered impaired will be offered a FIT test. If they fail, they will be considered as a suspect drug driver and examined by a forensic physician and a forensic sample obtained and analyzed if appropriate. Those who pass a FIT assessment will be asked to voluntarily supply a sample of saliva, which will be analyzed for drugs. The drug incidence in the two groups will then be compared, as will the police officers' and doctors' assessments using standardized proformas. The results are awaited with interest.

In Victoria, Australia *(93)*, forensic physicians with relevant qualifications and experience act as experts for the court by reviewing all the evidence of impaired driving, the police Preliminary Impairment Test, the forensic physician's assessment, and toxicological results and provide an opinion. So far, no expert opinions have been challenged in court. However, there were several inconsistencies in the physical examination with the drugs eventually found on toxicological examination, cases where the individual were barely conscious, where a formal assessment should not even have been considered, and missed medical and psychiatric conditions.

References

1. Finucane, A. K. Legal aspects of epilepsy. Neurol. Clin. 17:235–243, 1999.
2. Fitten, L. J. The demented driver: the doctor's dilemma. Alzheimer Dis. Assoc. Disord. 11 (Suppl 1):57–61, 1997.
3. Driver and Vehicle Licensing Agency. For Medical Practitioners: At a Glance Guide to the Current Medical Standards of Fitness to Drive. Drivers Medical Unit. DVLA, Swansea, Wales, 2003.

4. Austroads Assessing Fitness to Drive: Austroads Guidelines for Health Professionals and Their Legal Obligations. Austroads, Sydney, 1998.
5. Osawa, M., Nagasawa, T., Yukawa, N., et al. Sudden natural death in driving: case studies in the western area of Kanagawa. Nippon Hoigaku Zasshi. 52:315–318, 1998.
6. Cheng, L. H., Whittington, R. M. Natural deaths while driving: would screening for risk be ethically justified? J. Med. Ethics. 24:248–251, 1998.
7. Belkic, K., Emdad, R., Theorell, T. Occupational profile and cardiac risk: possible mechanisms and implications for professional drivers. Int. J. Occup. Med. Environ. Health. 11:37–57, 1998.
8. Conti, J. B., Woodard, D. A., Tucker, K. J., Bryant, B., King, L. C., Curtis, A. B. Modification of patient driving behavior after implantation of a cardioverter defibrillator. Pacing Clin. Electrophysiol. 20(9 Pt. 1):2200–2204, 1997.
9. Medical Research Council Antiepileptic Drug Withdrawal Study Group. Prognostic index for recurrence of seizures after remission of epilepsy. Br. Med. J. 306:1374–1378, 1993.
10. Krumholz, A. Driving and epilepsy: a historical perspective and review of current regulations. Epilepsia. 35:668–674, 1994.
11. MacLeod, K. M. Diabetes and driving: towards equitable, evidence-based decision-making. Diabetes Med. 16:282–290, 1999.
12. Ehrlich, E. N. Diabetes and the license to drive. Wis. Med. J. 90:115–118, 1991.
13. Distiller, L. A., Kramer, B. D. Driving and diabetics on insulin therapy. S. Afr. Med. J. 86 (Suppl 8):1018–1020, 1996.
14. Charman, W. N. Vision and driving–a literature review and commentary. Ophthalmic Physiol. Opt. 17:371–391, 1997.
15. General Medical Council. Duties of a Doctor–Confidentiality. Guidance from the General Medical Council. GMC, London, UK, 1995.
16. Ellenhorn, M. J., Schonwald, S., Ordog, G., Wasserberger, J. Ellenhorn's Medical Toxicology: Diagnosis and Treatment of Human Poisoning. Williams & Wilkins, Baltimore, MD, 1997.
17. Jones, A., Pounder, D. Measuring blood-alcohol concentration for clinical and forensic purposes. In: Karch, S., ed., Drug Abuse Handbook. CRC Press, Boca Raton, FL, pp. 327–356, 1998.
18. Noordzij, P. C., Roszbach, R. Alcohol, drugs, and traffic safety. In: T86: Proceedings of the 10th International Conference on Alcohol, Drugs, and Traffic Safety, Amsterdam, September 9–12, 1986. Excerpta Medica, New York, NY, 1987.
19. Borkenstein, R. F., Dale, A. The role of the drinking driver in traffic accidents. Department of Police Administration, Indiana University, Bloomington, IN, 1964.
20. Allsop, R. Alcohol and road accidents: a discussion of the Grand Rapids study: RRL 6. Transport and Road Research Laboratory, Crowthorne, UK, 1996.
21. Compton, R.P., Blomberg, R.D., Moskowitz, H., Burns, M., Peck, R.C., Fiorentino, D. Crash Risk of Alcohol Impaired Driving in T2002 Proceedings of the 16th International Conference on Alcohol, Drugs and Traffic Safety. Montreal, Canada, 2002.
22. California Code of Regulations. Title 13. Motor Vehicles and Traffic Regulations, CA, 1999.

23. Pounder, D., Jones, G. Measuring alcohol post-mortem. In: Karch, S., ed., Drug Abuse Handbook, CRC Press, Boca Raton, FL, pp. 356–374, 1998.
24. Aberg, L. Utzelmann, H. D., Berghaus, G., eds. Behaviours and opinions of Swedish drivers before and after the 0.02% legal BAC limit of 1990, in T9. Proceedings of the 12th International Conference on Alcohol, Drugs, and Traffic Safety, Cologne, Germany, 1992.
25. Department of Environment, Transport and the Regions. Combating Drunk-Driving—Next Steps. A Consultation Document. DETR, UK, 1998.
26. Dunbar, J. A., Penttila, A., Pikkarainen, J. Drinking and driving: success of random breath testing in Finland. Br. Med. J. 295:101–103. 1987.
27. Marsden, A. Accidental injury and traffic medicine. In: McLay, W. D. S., ed., Clinical Forensic Medicine, Greenwich Medical Media, London, UK, p. 231, 1996.
28. Coben, J. H., Larkin, G. L. Effectiveness of ignition interlock devices in reducing drunk driving recidivism. Am. J. Prev. Med. 16 (Suppl 1):81–87, 1999.
29. *Sheldrake v Director of Public Prosecutions* [2003] EWHC 273 (Admin).
30. *Pugh v Knipe.* R.T.R. 286. 1972.
31. *Wallwork v Giles.* 114 S.J. 36. 1969.
32. Krause, K. R., Howells, G. A., Bair, H. A., Bendick, P. J., Glover, J. L. Prosecution and conviction of the injured intoxicated driver. J. Trauma. 45:1069–1073, 1998.
33. McArthur, D. L., Kraus, J. F. The specific deterrence of administrative per se laws in reducing drunk driving recidivism. Am. J. Prev. Med. 16 (Suppl 1):68–75, 1999.
34. Association of Police Surgeons/British Medical Association. Taking blood from incapacitated drivers. Guidance for doctors on the provisions of the Police Reform Act 2002. Available at Website: (http://www.afpweb.org.uk/Pages/Publications-Guidelines&Advice.htm). Accessed on October 2002.
35. Kaye, S., Cardona, E. Errors of converting a urine alcohol value into a blood alcohol level. Am. J. Clin. Pathol. 52:577–584, 1969.
36. Winek, C. L., Esposito, F. M. Comparative study of ethanol levels in blood versus bone marrow, vitreous humor, bile and urine. Forensic Sci. Int. 17:27–36, 1981.
37. Carter, P. G., McConnell, A. A. Alcohol in drink driving swabs: does it make any difference? [letter]. Med. Sci. Law. 30:90, 1990.
38. *Chief Constable of Avon and Somerset v Singh.* R.T.R. 107. 1988.
39. *D.P.P. v Kinnersley.* The Times, December 29 D.C. 1992.
40. *D.P.P. v Pearman.* R.T.R. 407. 1992.
41. *Young v D.P.P.* R.T.R. 328. 1992.
42. Gomm, P. J., Osselton, M. D., Broster, C. G., Johnson, N. M., Upton, K. Study into the ability of patients with impaired lung function to use breath alcohol testing devices. Med. Sci. Law. 31:221–225, 1991.
43. Gomm, P. J., Broster, C. G., Johnson, N. M., Hammond, K. Study into the ability of healthy people of small stature to satisfy the sampling requirements of breath alcohol testing instruments. Med. Sci. Law. 33:311–314, 1993.
44. Odell, M., McDonald, C., Farrar, J., Natsis, J. S., Pretto, J. F. Breath testing in patients with respiratory disability. J. Clin. Forensic Med. 5:45–48, 1998.
45. Honeybourne, D., Moore, A. J., Butterfield, A. K., Azzan, L. A study to investigate the ability of subjects with chronic lung diseases to provide evidential breath samples

using the Lion Intoxilyzer ® 6000 UK breath alcohol testing device. Respiratory Med. 94:684–688, 2000.
46. Logan, B. K., Gullberg, R. G. Lack of effect of tongue piercing on an evidential breath alcohol test. J. Forensic Sci. 43:239–240, 1998.
47. *Kuldip Singh Gill v D.P.P.* January 16, 1995.
48. *Solesbury v Pugh.* 1 W.L.R. 1114. 1969.
49. *Bayliss v Thames Valley Police Chief Constable*. R.T.R. 328, 1978.
50. *Beck v Watson.* R.T.R. 91. 1980.
51. Robinson, S. P. Road traffic offences. In Robinson, S. P., ed., Principles of Forensic Medicine, Greenwich Medical Media, London. Distributed worldwide by Oxford University Press, Oxford, UK, pp. 139–147, 1996.
52. *R v Bolton JJ. Ex p. Scally* 1 Q.B. 537. 1991.
53. *R v Harding.* R.T.R. 325. 1974.
54. Stark, M.M., Brener, N. Needle Phobia. J. Clin. Forensic Med. 7:35–38, 2000.
55. Rix, K. Blood or needle phobia as a defence under the Road Traffic Act of 1988. J. Clin. Forensic Med. 3:173–177, 1996.
56. Jones, A. W. Top ten defence challenges among drinking drivers in Sweden. Med. Sci. Law. 31:229–238, 1991.
57. Jones, A., Logan, B. DUI defenses. In: Karch, S., ed., Drug Abuse Handbook , CRC Press, Boca Raton, FL, pp. 1006–1046, 1998.
58. *Rowland v. Thorpe.* 3 All E.R. 195. 1970.
59. Acevedo, C. G., Tamayo, L., Contreras, E. Effects of morphine in the isolated mouse urinary bladder. Gen. Pharmacol. 17:449–452, 1986.
60. Davis, A. R., Lipson, A. H. Central nervous system tolerance to high blood alcohol levels. Med. J. Aust. 144:9–12, 1986.
61. Felby, S., Olsen, J. Comparative studies of postmortem ethyl alcohol in vitreous humor, blood, and muscle. J. Forensic Sci. 14:93–101, 1969.
62. Seppala, T., Linnoila, M., Mattila, M. J. Drugs, alcohol and driving. Drugs. 17:389–408, 1979.
63. Mattila, M. J., Vanakoski, J., Kalska, H., Seppala, T. Effects of alcohol, zolpidem and some other sedatives and hypnotics on human performance and memory. Pharmacol. Biochem. Behav. 59:917–923, 1998.
64. Ramaekers, J. G. Behavioural toxicity of medicinal drugs. Practical consequences, incidence, management and avoidance. Drug Saf. 18:189–208, 1998.
65. Osselton, M. D., Owen, P., Fysh, R. Drugs and Driving, Forensic Science Service Report No. TN816. Forensic Science Service, London, UK, p. 3, 1996.
66. Tunbridge, R. J., Keigan, M., James, F. J. The Incidence of Drugs in Road Accident Fatalities. TRL report 495. TRL Ltd, Crowthorne, UK, 2001.
67. Everest J. T., Tunbridge, R. J., B.Widdop. The Incidence of Drugs in Road Accident Fatalities. TRL Report RR202. Transport and Road Research Laboratory, Crowthorne, UK, 1989.
68. Berghaus, G., Scheer, N., Schmidt, P. Effects of cannabis on psychomotor skills and driving performance–a meta-analysis of experimental studies, in T95 Proceedings of the 13th International Conference on Alcohol, Drugs, and Traffic Safety, Adelaide, 1994.

69. Chait, L., Pierri, J. Effects of smoked marijuana on human performance: a critical review. In: Murphy, L., Bartke, A., eds., Marijuana/Cannabinoids: Neurobiology and Neurophysiology. CRC Press, Boca Raton, FL, 1992.
70. Heishman, S., Karch, S. Drugs and driving. In: Siegel, J., Saukko, P., Knupfer, G., eds., Encyclopaedia of Forensic Sciences. Academic Press, London, UK, 2000.
71. Heishman, S. J., Singleton, E. G., Crouch, D. J. Laboratory validation study of drug evaluation and classification program: alprazolam, δ-amphetamine, codeine, and marijuana. J. Anal. Toxicol. 22:503–514, 1998.
72. Sexton, B.F., Tunbridge, R.J., Brook-Carter, N., et al. The influence of cannabis on driving. TRL Report 477. TRL Limited, Crowthorne, UK, 2000.
73. Friedel, B., Berghaus, S. Methadone and Driving. In: T95 Proceedings of the 13th International Conference on Alcohol, Drugs, and Traffic Safety, Adelaide, Australia, 1995.
74. Koelega, H. S. Stimulant drugs and vigilance performance: a review. Psychopharmacology. 111:1–16, 1993.
75. Farre, M., Llorente, M., Ugena, B., Lamas, X., Cami, J. Interaction of cocaine with ethanol. NIDA Res Monogr. 105:570–571, 1991.
76. Logan, B. K. Methamphetamine and driving impairment. J. Forensic Sci. 41:457–464, 1996.
77. De Waard, D., Brookhuis, K. A., Pernot, L. M. C. A driving simulator study on the effects of MDMA (Ecstasy) on driving performance and traffic safety. In: T2000 Proceedings of the International Conference on Alcohol, Drugs, and Traffic Safety, Stockholm, Sweden, May 26, 2000.
78. O'Hanlon, J. F., Vermeeren, A., Uiterwijk, M. M., van Veggel, L. M., Swijgman, H. F. Anxiolytics' effects on the actual driving performance of patients and healthy volunteers in a standardized test. An integration of three studies. Neuropsychobiology. 31:81–88, 1995.
79. Barbone, F., McMahon, A. D., Davey, P. G., et al. Association of road-traffic accidents with benzodiazepine use [see comments]. Lancet. 352:1331–1336, 1998.
80. Bramness, J. G., Skurtveit, S., Mørland. J. Clinical Impairment of Benzodiazepines–Relation between Benzodiazepine Concentrations and Impairment in Apprehended Drivers. Pompidou Group, Strasbourg, France, 2003.
81. Chesher, G. B., Dauncey, H., Crawford, J., Horn, K. The Interaction Between Alcohol and Marijuana. Report to the Australian Federal Office of Road Safety. Department of Pharmacology, University of Sydney, Sydney, Australia, 1996.
82. Sexton, B. F., Tunbridge, R. J., Brook-Carter, N., et al. The influence of cannabis and alcohol on driving. TRL Report 543. TRL Limited, Crowthorne, UK, 2002.
83. Hindmarch, I. Psychiatry in practice. Winter:23–25, 1993.
84. O'Hanlon, J. F., Robbe, H. W., Vermeeren, A., van Leeuwen, C., and Danjou, P. E. Venlafaxine's effects on healthy volunteers' driving, psychomotor, and vigilance performance during 15-day fixed and incremental dosing regimens. J. Clin. Psychopharmacol. 18:212–221, 1998.
85. Bhatti, J. Z., Hindmarch, I. The effects of terfenadine with and without alcohol on an aspect of car driving performance. Clin. Exp. Allergy. 19:609–611, 1989.

86. Tunbridge, R. J., Keigan, M., James, F. J. Recognising drug use and drug related impairment in drivers at the roadside. TRL report 464. TRL Ltd, Crowthorne, UK, 2001.
87. Burns, M., Adler, E. Study of a Drug Recognition Expert (DRE) program, in T95. Proceedings of the 13th International Conference on Alcohol, Drugs, Traffic Safety, Adelaide, Australia, 1995.
88. Kidwell, D. A., Holland, J. C., Athanaselis, S. Testing for drugs of abuse in saliva and sweat. J. Chromatogr. B Biomed. Sci. Appl. 713:111–135, 1998.
89. Tunbridge, R. J., Rowe, D. J. Roadside identification of drug impaired drivers in Great Britain. 10th International Conference on Road safety in Europe, Malmo, 1999.
90. O'Keefe, M. Drugs driving—standardized field sobriety tests: a survey of police surgeons in Strathclyde. J. Clin. Forensic Med. 8:57–65, 2001.
91. *Leetham v. D.P.P.* Q.B. 488. 1998.
92. Stark, M. M., Tunbridge, R. J., Rowe, D., Fleming, D., Stewart, D. Drugs, driving and sobriety tests–a review of recent developments. J. Clin. Forensic Med. 9:126–132, 2002.
93. Odell, M.S. Expert Opinion in DUID Cases Based on Interpretation and Observation and Toxicology in T2002. Proceedings of the 16th International Conference on Alcohol, Drugs and Traffic Safety. Montreal, Canada, 2002.