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Society Guidelines

Canadian Cardiovascular Society 2023 Guidelines on the Fitness to Drive

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ABSTRACT

Cardiovascular conditions are among the most frequent causes of impairment to drive, because they might induce unpredictable mental state alterations via diverse mechanisms like myocardial ischemia, cardiac arrhythmias, and vascular dysfunction. Accordingly, health professionals are often asked to assess patients' fitness to drive (FTD). The Canadian Cardiovascular Society previously published FTD guidelines in 2003-2004; herein, we present updated FTD guidelines. Because there are no randomized trials on FTD, observational studies were used to estimate the risk of driving impairment in each situation, and recommendations made on the basis of Canadian Cardiovascular

RÉSUMÉ

Les affections cardiovasculaires sont parmi les causes les plus fréquentes de l'inaptitude à la conduite, en raison des altérations imprévisibles de l'état mental qu'elles peuvent entraîner par plusieurs mécanismes comme l'ischémie myocardique, les arythmies cardiaques et la dysfonction vasculaire. Les professionnels de la santé sont donc fréquemment amenés à évaluer l'aptitude à conduire (AC) des patients. En 2003-2004, la Société cardiovasculaire du Canada avait publié des lignes directrices sur l'évaluation de l'AC. Nous présentons ici une mise à jour de ces lignes directrices sur l'évaluation de l'AC. Faute d'essais à répartition aléatoire sur l'AC, nous avons eu recours à

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The disclosure information of the authors and reviewers is available from the CCS on their guidelines library at www.ccs.ca.

This statement was developed following a thorough consideration of medical literature and the best available evidence and clinical experience. It represents the consensus of a Canadian panel comprised of multidisciplinary experts on this topic with a mandate to formulate disease-specific recommendations. These recommendations are aimed to provide a reasonable and practical approach to care for specialists and allied health professionals obliged with the duty of bestowing optimal care to patients and families, and can be subject to change as scientific knowledge and technology advance and as practice patterns evolve. The statement is not intended to be a substitute for physicians using their individual judgement in managing clinical care in consultation with the patient, with appropriate regard to all the individual circumstances of the patient, diagnostic and treatment options available and available resources. Adherence to these recommendations will not necessarily produce successful outcomes in every case.

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Society Risk of Harm formula. More restrictive recommendations were made for commercial drivers, who spend longer average times behind the wheel, use larger vehicles, and might transport a larger number of passengers. We provide guidance for individuals with: (1) active coronary artery disease; (2) various forms of valvular heart disease; (3) heart failure, heart transplant, and left ventricular assist device situations; (4) arrhythmia syndromes; (5) implantable devices; (6) syncope history; and (7) congenital heart disease. We suggest appropriate waiting times after cardiac interventions or acute illnesses before driving resumption. When short-term driving cessation is recommended, recommendations are on the basis of expert consensus rather than the Risk of Harm formula because risk elevation is expected to be transient. These recommendations, although not a substitute for clinical judgement or governmental regulations, provide specialists, primary care providers, and allied health professionals with a comprehensive list of a wide range of cardiac conditions, with guidance provided on the basis of the level of risk of impairment, along with recommendations about ability to drive and the suggested duration of restrictions.

des études observationnelles pour évaluer le risque d'inaptitude à la conduite dans chacune des situations, et nous avons formulé des recommandations fondées sur la formule d'analyse du risque de préjudice de la Société cardiovasculaire du Canada. Des recommandations plus contraignantes concernent les personnes qui conduisent des véhicules commerciaux, puisqu'elles passent en moyenne de plus longues périodes au volant, conduisent des véhicules de plus grande taille et peuvent être responsables du transport d'un plus grand nombre de passagers. Les lignes directrices visent les populations présentant les affections suivantes : 1) coronaropathie active; 2) différentes formes de valvulopathies; 3) insuffisance cardiaque, greffe cardiaque et recours à un dispositif d'assistance ventriculaire gauche; 4) syndromes d'arythmie; 5) dispositifs implantables; 6) antécédents de syncope; et 7) cardiopathie congénitale. Nous recommandons une attente d'une durée adéquate après une intervention cardiaque ou une maladie aiguë avant la reprise de la conduite. Lorsqu'un arrêt de la conduite à court terme est indiqué, les recommandations formulées reposent sur un consensus d'experts plutôt que sur la formule d'analyse du risque de préjudice en raison de la nature présumée temporaire de l'élévation du risque. Ces recommandations ne peuvent remplacer le jugement clinique ni la réglementation gouvernementale, mais elles offrent aux médecins spécialistes, aux omnipraticiens et aux autres professionnels de la santé une liste contenant un large éventail d'affections cardiaques et des lignes directrices fondées sur le niveau de risque de l'inaptitude, ainsi que des recommandations sur l'aptitude à conduire et des suggestions sur la durée des restrictions à imposer.

In 1992, the Canadian Cardiovascular Society (CCS) consensus conference document, "Assessment of the Cardiac Patient for Fitness to Drive," was published.[1] Four years later, as a result of significant advances in the investigation and management of arrhythmias and syncope, an update was deemed necessary by the CCS Task Force that penned the original document.[2] In 2002, after receiving suggestions from the CCS membership, the CCS Council selected "fitness to drive and fly" as the consensus conference topic for 2003-2004.[3,4] In 2012, a CCS focused position statement on left ventricular assist devices (LVADs) was published, to respond to new evidence that event rates in this population were lower than previously believed.[5] Most recently, the CCS membership perceived that a further update was required, because significant developments had again occurred in the evaluation and treatment of cardiac disorders, rendering some of the recommendations outdated or obsolete.

Physicians and some other health care professionals in many Canadian jurisdictions are required by law to report patients who are potentially unfit to drive because of their disease or condition. Legislation in 7 of 10 provinces and all 3 territories requires that physicians report to the regulatory authorities, patients who might pose a risk on the road because of their medical condition (the remaining jurisdictions have discretionary reporting systems). Reporting has become an integral part of the risk assessment process for most Canadian physicians and other health care professionals who provide care for cardiac patients. These guidelines are formulated on the best evidence available to guide risk assessment and reporting, as legally required. Furthermore, these guidelines fill a gap in knowledge synthesis pertaining to the risk of sudden incapacitation across cardiovascular conditions. The updated recommendations have taken into consideration estimates of risk in patients on contemporary therapy for cardiovascular diseases. Risk is estimated on the basis of the best available estimated event rates observed in registries, administrative data sets, and the "control groups" of pragmatic trials. Some of the event rates that were studied are by necessity surrogates for sudden incapacitation and include sudden death, malignant ventricular arrythmias, defibrillator therapy, and syncopal episodes. When insufficient evidentiary data were available, recommendations were made on the basis of common best practices and historical deference to caution with writing subgroup expert consensus (this is particularly true for postprocedural recommendations). When possible, sex differences in risk estimates are provided.

These guidelines are not a substitute for physicians using their clinical judgement and assessment of risk in clinical settings with appropriate regard to the individual circumstances, values and preferences of the patient, and the diagnostic and treatment options available. Adherence to these recommendations will reduce, but not eliminate risk.

The 2023 Fitness to Drive guidelines follow a series of virtual meetings of cardiovascular researchers and clinicians. The members were selected on the basis of contributions to previous guidelines and current areas of clinical and research expertise, with a view to representativeness across cardiac subspecialties, gender, generation, and geography.

Risk of Harm Formula

Under the leadership of Dr Jim Brennan, the original task force developed the ground-breaking "Risk of Harm" formula (which, for the first time, allowed the assignment of a quantitative level of risk to drivers with cardiac disease). The development of this quantitative approach included definition of the risk that society had historically considered to be acceptable. This standard of acceptable risk served as the benchmark against which all other drivers with cardiac disease could be measured. Although arbitrary, this benchmark of acceptable risk has stood the test of time, from a general acceptability point of view, and remains, to our knowledge, the only quantitative estimate of society's tolerance for risk in the medical fitness to drive literature.

The reader is encouraged to refer to the original document for the derivation of the Risk of Harm formula.[3,4] On the basis of the available literature, it was determined that a commercial driver (a tractor trailer operator, for example) who faces a 1% risk of sudden cardiac incapacitation (SCI) in the next year poses a 1 in 20,000 risk of death or serious injury to other road users or bystanders. Set as the standard, this annual 1 in 20,000 risk can be applied in turn to a private driver to determine the annual risk of SCI that would pose the same overall risk to society. Because private drivers spend much less time on the road, and because they drive vehicles that are less likely to cause harm in the event that an accident actually does occur, it can be calculated that a private driver with a 22% annual risk of SCI also poses a risk to society of 1 in 20,000. Therefore, a private driver with a 22% chance of having a suddenly incapacitating event in the next year poses no greater risk to society than does a tractor trailer driver with a 1% chance of having a suddenly incapacitating cardiac event over the same time period.

Because no licensing jurisdiction has quantified the acceptable risk in legislation or regulations, any standard risk threshold used in any expert guidance might be considered as somewhat arbitrary. However, arriving at a standard risk threshold has allowed us to apply consistent and fair recommendations across different cardiac conditions and across different classes of licenses. In addition, the standard risk threshold, originally calculated by the CCS in 1996,[2] has remained consistent over time as evidenced by its uptake by successive published editions of the Canadian Medical Association Drivers Guide[6] and the Canadian Council of Motor Transport Administrators National Safety Code[7] (documents widely used by government regulatory authorities to adjudicate individual fitness to drive). To our knowledge, no other quantified "acceptable" level of risk has been suggested, tested, or accepted. For these reasons, the panel opted to continue with the use of this historical standard risk threshold in the development of this updated guideline.

The current recommendations reflect new information that has become available in the literature over the intervening years, but the Risk of Harm formula remains the major assessment tool. In addition to assessing level of risk compared with a standard level of acceptable risk, it also allows for consistency across the breadth of recommendations.

Level of Evidence

Literature reviews were undertaken to generate risk estimates, and data sources for these estimates were selected on the basis of consensus of experts in each cardiovascular field. There are no prospective, controlled studies in which patients had been randomized to permit or to proscribe the driving privilege nor where patients had been randomized to receive or not to receive physician advice not to drive. Furthermore, the acceptable threshold of risk used in this document (although sensibly derived as previously described herein) is consensus-based. For this reason, the current guidelines do not follow the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) methodology. Additionally, we have chosen to formulate general, overarching clinical questions as an introduction to each section because structured population, intervention, control, and outcomes (PICO) questions did not apply to the available data.

The recommendations for driving eligibility are made on the basis of a comparison with the previously stated threshold, but the risk estimates are made on the basis of the best and most recent available evidence. This evidence was used to estimate risk of sudden incapacitation or a reasonable surrogate, as described in the introductory section, when this evidence was lacking. However, the evidence does not speak to the actual risk of driving or collision rates associated with the cardiac diagnosis, the benefit of driving cessation, or the effect of the system of mandatory reporting of and formal license suspension for such patients.

The panel has made an effort to consider the inherently subjective nature of society's tolerance for risk, while also applying a scientifically based risk assessment mechanism in an effort to make the recommendations not just acceptable to society, but also consistent and justifiable. It is noteworthy, however, that existing guidelines for other medical conditions outside those considered in these guidelines (ie, for noncardiac medical conditions) have been developed by other experts and associations using different approaches and methodologies. The consistency with these other recommendations has not been assessed.

Important Considerations in the Fitness to Drive Guidelines

1. Because there are no prospective, randomized trials on fitness to drive and risk of sudden incapacitation, the recommendations are mostly on the basis of observational data from studies on various cardiac conditions, making the level of evidence moderate.
2. When evidence was not available, consensus-based recommendations were made by each of the individual subgroups on the basis of best practices, historical practice, and deference to safety.
3. In many instances, because no specific data on SCI exist, best reasonable surrogates such as sudden death, ventricular arrhythmias (VAs), defibrillator therapies, and syncope were used to estimate risk.
4. The Risk of Harm formula was used to describe an acceptable threshold level of risk for private and commercial drivers (22% risk of SCI within the year and 1% risk of SCI within the year, respectively).

Because of these particularities, it was decided to forego the GRADE methodology and PICO questions because these were not deemed applicable with the available evidence and the structure of our recommendations.

Specific Recommendations

The tables of recommendations list the disease- and condition-specific guidelines. The tables are shown throughout this document, along with a list of specific definitions that have been adopted for use in this document. Recommendations are given for private and commercial drivers. Figure 1 shows a summary in graphic form of 6 of the more common conditions in which physicians are asked to assess a patient's fitness to drive. Emphasis is placed on assessment of symptom burden using physician-reported tools such as the New York Heart Association (NYHA) classes because these were used to classify symptoms and as eligibility criteria in clinical trials and registries; however, it is recognized that patient-reported outcome measures of health status might be more reliable markers of risk.[8] In general, if a patient has more than 1 concurrent condition, the most restrictive recommendation should be applied.

The document is divided into 7 sections:

1. Coronary artery disease (CAD): Acute coronary syndrome (ACS), post myocardial infarction (MI), stable angina, and coronary artery bypass graft (CABG) surgery
2. Valvular heart disease
3. Heart failure (HF), transplantation, LVADs
4. Inherited arrhythmia syndromes and cardiomyopathies
5. Rhythm and devices: Cardiac implantable electronic devices (CIEDs), bradyarrhythmias, and tachyarrhythmias
6. Syncope
7. Congenital and cyanotic heart disease

1. CAD: ACS, Post MI, Stable Angina, and CABG Surgery

Question 1: In persons who have had an MI, or have stable angina, and/or have had coronary revascularization in the form of percutaneous coronary intervention (PCI) or CABG surgery and survived to discharge and with follow-up, what is the risk of sudden cardiac death (SCD) within 1 year? Where possible, stratify according to sex, age, and left ventricular ejection fraction (LVEF). In this section, SCD serves as the surrogate for SCI.

ACS—STEMI and NSTEMI

The risk of incapacitation after ACS is predominately related to the risk of SCD. More contemporary reports provide mortality rates but not the rate of sudden deaths. Significantly reduced LVEF, rather than type of ACS (ST segment elevation MI [STEMI] vs non-STEMI [NSTEMI]), is the most widespread clinical identifier of patients at increased risk for SCD after ACS.[9] Recommendations for driving after ACS are summarized in Table 1.

Patients with LVEF ≤ 40%. The **Val**sartan **i**n **A**cute Myocardial **I**nfarc**t**ion (VALIANT) trial enrolled > 14,000 post-MI patients between 1998 and 2001 with LVEF ≤ 40% according to radionuclide ventriculogram or ≤ 35% according to echocardiogram and/or clinical or radiological signs of HF.[10] The 30-day and 1-year incidence of SCD was 1.4% and 2.17%, respectively. Similarly, a post-MI registry of

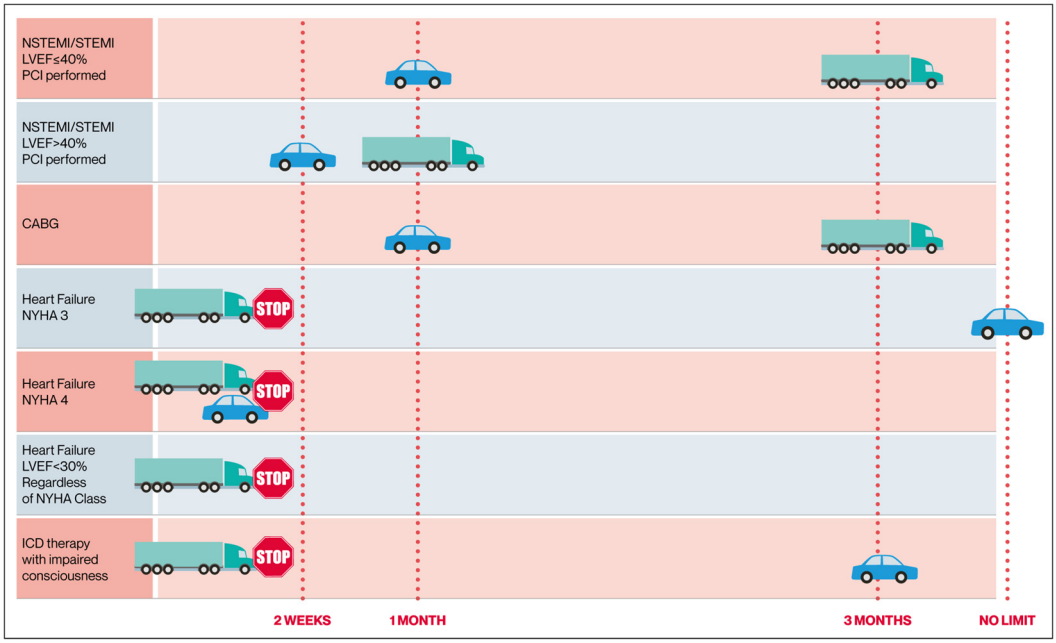

Figure 1. Fitness to drive quick reference for common conditions. Graphic illustration of 7 commonly inquired about conditions with relation to cardiac fitness to drive (infarct, bypass surgery, heart failure, defibrillator shocks). The **car** represents private driving, and the **truck** represents commercial driving (for sake of illustration, this is meant to convey all types of commercial licenses). The timeline on the **horizontal axis** shows when driving can resume. The **"stop" sign** signifies complete disqualification. CABG, coronary artery bypass grafting; ICD, implantable cardioverter defibrillator; LVEF, left ventricular ejection fraction; NSTEMI, non-ST-elevation myocardial infarction; NYHA, New York Heart Association; SAVR, surgical aortic valve replacement; STEMI, ST-elevation myocardial infarction.

Table 1. Recommendations for fitness to drive with CAD

Condition	Private driving	Commercial driving
ACS: PCI performed		
STEMI, LVEF ≤ 40%	May resume driving after 1 month	May resume driving after 3 months
STEMI, LVEF > 40%	May resume driving after 2 weeks	May resume driving after 1 month
NSTEMI, LVEF ≤ 40%	May resume driving after 1 month	May resume driving after 3 months
NSTEMI, LVEF > 40%	May resume driving after 2 weeks	May resume driving after 1 month
ACS without MI (unstable angina)	May resume driving after 48 hours	May resume driving after 7 days
ACS: PCI not performed		
STEMI	May resume driving after 1 month	May resume driving after 3 months
NSTEMI	May resume driving after 1 month	May resume driving after 3 months
ACS without MI (unstable angina)	May resume driving after 7 days	May resume driving after 1 month
Chronic CAD		
Stable angina or asymptomatic CAD*	No restriction	No restriction
PCI (in a non-ACS context)	May resume driving after 48 hours	May resume driving after 48 hours
Cardiac surgery		
CABG surgery	May resume driving after 1 month	May resume driving after 3 months

ACS, acute coronary syndrome; CABG, coronary artery bypass grafting; CAD, coronary artery disease; LVEF, left ventricular ejection fraction; MI, myocardial infarction; NSTEMI, non-ST-segment elevated MI; PCI, percutaneous coronary intervention; STEMI, ST-segment elevated MI.

*Angiographic demonstration of ≥ 50% reduction in the diameter of the left main coronary artery should disqualify the patient from commercial driving, and ≥ 70% reduction in the diameter of the left main should disqualify the patient for private driving, unless treated with revascularization.

nearly 3000 patients from 1997 to 2005 showed the incidence of SCD to be 1.2% and 3.0% at the same time points.[11] However, considering the time frame, less than half received definitive revascularization (PCI or CABG) for their ACS; this might not necessarily reflect contemporary care. In contrast, in the more recent **V**est Prevention of **E**arly **S**udden Death **T**rial (VEST) 2302 participants with LVEF ≤ 35% were randomly assigned to a wearable cardioverter-defibrillator in a 2:1 fashion within 7 days after MI discharge.[12] The incidence of SCD remained relatively high at 2.4% at 90 days. In contrast, a contemporary observational study of > 120,000 patients from the **S**wedish **W**eb-System for **E**nhancement and **D**evelopment of **E**vidence-Based Care in **H**eart Disease **E**valuated **A**ccording to **R**ecommended **T**herapies (SWEDEHEART) registry, which enrolled patients from 2009 to 2017 (77% revascularized) showed that the incidence of SCD among patients with LVEF ≤ 40% to be 0.76% at 3 months.[13] Therefore, because rates of SCD remain high (exceeding the acceptable threshold of 1% annually) even in the modern era among patients with LVEF ≤ 40%, it is reasonable to continue to restrict commercial driving for 3 months post-MI.

Patients with LVEF > 40%. Contemporary registries comprising post-MI patients with normal EF (or most with normal EF) and high rates of revascularization have shown that the risk of SCD ranged from 0.5% to 0.6% at 1 year.[14,15] Secondary analyses of recent clinical trials with most patients having a normal or mildly reduced EF, have shown that the risk of SCD ranged from 0.6% to 1.1% at 1 year, but that approximately 25% of SCD occurred in the first month, suggestive that monthly rates were much lower thereafter.[16,17] In the contemporary SWEDEHEART registry, the rate of SCD was approximately 0.2% after 1 month and remained similar at 3 months.[13] This suggests that the rate of SCD between 1 and 3 months was far below the 0.083% per month (1% annually) acceptable threshold and favours an easing of driving restrictions in the subgroup of post-MI patients with LVEF > 40%.

ACS—unstable angina

Although the incidence of SCD after hospitalization for unstable angina compared with STEMI or NSTEMI has not been recently reported, the differential risk across types of ACS can be extrapolated from studies that evaluated overall or cardiovascular death. Rates of SCD among patients admitted with unstable angina are likely low. Data from the **G**lobal **R**egistry of **A**cute **C**oronary **E**vents (GRACE) study of 19,122 patients from 2004 to 2007 showed that 6-month mortality was 4.0% (700 of 17,598 patients), with most (71.3%) due to cardiovascular causes. At 2-year follow-up, the incidence of cardiovascular death (which includes SCD) among patients with unstable angina (28% of the cohort) was 2.6% compared with 5.2% for NSTEMI or 3.7% for STEMI.[18] The relatively lower risk of death in patients with unstable angina compared with other forms of ACS is consistent with findings from another 6-month postdischarge GRACE study cohort.[19] Considering the low event rate, the consensus opinion was to proscribe driving only for 48 hours out of an abundance of caution for patients with a new ACS (likely having been hospitalized) who underwent an intervention and for 7 days in those without an intervention.

Chronic CAD and stable angina

The rates of SCD in patients with stable angina are also likely low, and driving recommendations in the setting of chronic CAD are summarized in Table 1. In the **P**revention of **E**vents with **A**ngiotensin **C**onverting **E**nzyme Inhibition (PEACE) trial, which enrolled patients with stable CAD and normal left ventricular function, the rate of SCD was 1.5% after a median follow-up of 4.8 years.[20] Similarly, the Innovation to Reduce Cardiovascular Complications of Diabetes at the Intersection Study (ARTEMIS), which enrolled consecutive Finnish patients who had undergone coronary angiography 3-6 months earlier (> 3 months post-ACS), showed a rate of SCD of 2.5% after a median follow-up of 6.3 years.[21] There is a paucity of contemporary Canadian registry data on SCD, as opposed to all-cause or

cardiovascular death, but reported rates of mortality in Canadians with stable CAD suggest that the risk for SCD is likely well < 1% per year.[22,23] Pivotal clinical trials on the role of PCI among patients with stable CAD did not explicitly evaluate the incidence of SCD in follow-up.[24-26] As such, no restrictions are suggested for patients with stable or asymptomatic coronary disease.

CABG surgery

The **Syn**ergy Between Percutaneous Coronary Intervention With **Tax**us and Cardiac Surgery (SYNTAX) trial, which compared the causes of death after PCI (n = 871) vs CABG (n = 805) in patients with complex CAD, showed that patients who underwent CABG had a 0.9% 30-day risk of SCD, a 1.5% 1-year risk of SCD, and a 1.9% risk of SCD at 5 years.[27] The relatively low rate of use of implantable cardioverter defibrillators (ICDs) in SYNTAX might have contributed to these findings. Other studies showed lower rates of SCD post CABG surgery. The **C**oronary **Re**vascularization **D**emonstrating **O**utcome Study in **Kyoto** (CREDO-Kyoto) PCI/CABG registry study showed that rates of SCD were only 0.3% at 1 year after CABG for multivessel CAD (n = 2910). In a separate cohort of the CREDO-Kyoto PCI/CABG registry study, on 5-year outcomes of PCI vs CABG,[28] rates of SCD at 5 years were 2.2% for triple-vessel CAD (n = 1154) and 1.6% for unprotected left main disease post CABG (n = 640). In the **B**ypass **A**ngioplasty **R**evascularization **I**nvestigation in Type **2 D**iabetes (BARI 2D) study,[29] which included > 7.7 years of follow-up for 2239 patients after CABG surgery, the rate of SCD was 2.4%.

Studies of patients with LVEF of < 35% who underwent CABG include the **S**urgical **T**reatment for **I**schemi**c** **H**eart Failure (STICH) trial,[30] which showed that among 1411 patients who underwent CABG that the risk of SCD was 0.35% at 30 days, 1.2% at 3 months, 2.0% at 6 months, and 2.8% at 1 year. In a national study of post-CABG individuals with wearable cardioverter defibrillators and an LVEF ≤ 35% (n = 243), the percentage who experienced SCD at 1 month was 0.09%, 0.10% at 3 months, and 0.26% at 1 year. A report on an aggregate national experience of individuals with wearable cardioverter defibrillators reported on the SCD of post-CABG patients with an LVEF ≤ 35% (n = 243); extrapolating from the survival charts the percentage who experienced SCD at 1 month was 0.09%, 0.10% at 3 months, and 0.26% at 1 year.

Sex-specific recommendations

None of the studies reviewed stratified SCD according to sex, and therefore no sex-specific recommendations can be made. In all of the studies, the most of the subjects were men, and there remains a paucity of studies on SCD in women with CAD. Women generally appear to have a lower incidence of SCD than men, even after adjustment for cardiovascular risk factors and across age.[31] However, in studies on STEMI patients, women were reported to present at older ages, receive fewer interventions, and have higher mortality rates compared with men.[32] It remains unknown whether these sex disparities in outcomes relate to differences in physiology or clinical treatment. Further studies are needed.

Practical tips:

- For patients after CABG surgery or PCI, driving restrictions are for the duration listed from surgical/procedural date. For patients admitted to hospital but not undergoing an intervention, driving restrictions are for the duration listed following discharge from hospital.
- For patients with an ACS but with only non-obstructive CAD found at coronary angiography, without additional data to guide decision making, it is reasonable to manage patients as if they were revascularized and let left ventricular function guide further decision-making.

2. Valvular Heart Disease

Question 2: In adult persons living with valvular heart disease, either untreated or surviving to discharge post invasive treatment with follow-up after invasive treatment of valvular heart disease that includes ascertainment of SCD, what is the risk of SCI (including SCD, heart block, and syncope) within 1 year? Where possible, stratify according to sex, age, and LVEF.

Fitness to drive with valvular heart disease is determined according to the nature of the valve disease, development of symptoms, and the risk of operating a motor vehicle (Table 2). In most cases, a patient's functional status can guide driving recommendations because valvular heart disease might present with symptoms of HF and increase the risk of arrhythmias. SCI in this group of patients is largely related to the risk of ventricular arrythmias or SCD in patients with diminished EF or the risk of syncope due to advanced conduction system disease or heart block. For patients with left ventricular dysfunction, driving restrictions are analogous with those for patients with HF. After successful intervention, either transcatheter or surgical, driving may be resumed according to the type of intervention performed and recuperation required after the intervention. There is a lack of large scale, detailed driving-specific data in patients with either treated or untreated valvular heart disease. Because of the multiple nuances in patients with mixed valvular heart disease, concomitant CAD, or concomitant severe ventricular dysfunction, involvement of the expert multidisciplinary structural heart team will be required for some patient-specific driving recommendations.

Aortic stenosis

Aortic valve stenosis is the most common valvular heart disease in North America and Europe with the prevalence increasing as the population ages. Although up to one-half of patients with aortic stenosis are asymptomatic at the time of diagnosis, the incidence of sudden death is reported as approximately 1% per year. Mortality is strongly correlated with symptomatic status, including dyspnea, angina, and syncope, as well as arrhythmias. Furthermore, syncope is also a potential source of incapacitation in these patients. One single-centre study estimated the incidence of syncope in patients who were candidates for transcatheter aortic valve replacement (TAVR) was 7%.[33] Additionally, there has been a temporal increase in aortic stenosis as a cause of HF in men and women across the world.[34] Commercial driving is

Table 2. Recommendations for fitness to drive with valvular heart disease

Condition	Private driving	Commercial driving
Medically treated valvular heart disease		
Aortic stenosis	No restriction if: • NYHA class I-II Disqualified if: • NYHA class III-IV	No restriction if: • NYHA class I and; • No episodes of impaired level of consciousness and; • LVEF $\geq$ 50% Otherwise disqualified
Aortic regurgitation	No restriction if: • NYHA class I-III Disqualified if: • NYHA class IV	No restriction if: • NYHA class I and; • No episodes of impaired level of consciousness and; • LVEF $\geq$ 50% Otherwise disqualified
Mitral regurgitation	No restriction if: • NYHA class I-III Disqualified if: • NYHA class IV	No restriction if: • NYHA class I and; • No episodes of impaired level of consciousness and; • LVEF $\geq$ 50% and; • No history of pulmonary hypertension or systemic embolism Otherwise disqualified
Mitral stenosis	No restriction if: • NYHA class I-III Disqualified if: • NYHA class IV	No restriction if: • NYHA class I and; • No episodes of impaired level of consciousness Otherwise disqualified
Tricuspid regurgitation	No restriction if: • NYHA class I-III Disqualified if: • NYHA class IV	No restriction if: • NYHA class I and; • No episodes of right-sided HF, or symptomatic sustained arrhythmia and; • No right ventricular dysfunction and; • LVEF $\geq$ 50% Otherwise disqualified
Valvular heart disease treated with transcatheter therapy (these recommendations pertain to postprocedural driving status; for patients with persistent advanced HF refer to *Heart Failure* section)		
Aortic stenosis (treated with TAVR)	May resume driving 1 month after procedure if: • Stable QRS duration* and no high-grade atrioventricular block† in the absence of a permanent pacemaker and; • NYHA class I-III	May resume driving 3 months after procedure if: • Stable QRS duration* and no high-grade atrioventricular block† in the absence of a permanent pacemaker and; • NYHA class I • LVEF > 30% Otherwise disqualified
Aortic regurgitation (TAVR)	May resume driving 1 month after procedure if: • Stable QRS duration* and no high-grade atrioventricular block† in the absence of a permanent pacemaker and; • NYHA class I-III	May resume driving 3 months after procedure if: • Stable QRS duration* and no high-grade atrioventricular block† in the absence of a permanent pacemaker and; • NYHA class I and; • LVEF $\geq$ 30% Otherwise disqualified
Mitral regurgitation (treated with TEER)‡	May resume driving 48 hours after procedure if: • NYHA class I-III	May resume driving 1 month after procedure if: • NYHA class I and; • LVEF $\geq$ 30% Otherwise disqualified
Mitral regurgitation (treated with TMVR)	May resume driving 1 month after procedure if: • NYHA class I-III	May resume driving 3 months after procedure if: • NYHA class I and; • LVEF $\geq$ 30% Otherwise disqualified
Mitral stenosis (treated with PBMV)‡	May resume driving 48 hours after procedure if: • NYHA class I-III	May resume driving 1 month after procedure if: • NYHA class I Otherwise disqualified
Tricuspid regurgitation (treated with TEER)‡	May resume driving 48 hours after procedure if: • NYHA class I-III	May resume driving 1 month after procedure if: • NYHA class I • LVEF $\geq$ 30% Otherwise disqualified

Table 2. Continued.

Condition	Private driving	Commercial driving
Tricuspid regurgitation (treated with TTVR)	May resume driving 1 month after procedure if: • NYHA class I-III	May resume driving 3 months after procedure if: • NYHA class I • LVEF $\geq$ 30% Otherwise disqualified
Surgically treated valve disease		
Aortic stenosis (treated with SAVR)	May resume driving 1 month after surgery if: • Stable QRS duration* and no high-grade atrioventricular block† in the absence of a permanent pacemaker and; • NYHA class I-III Otherwise disqualified	May resume driving 3 months after surgery if: • Stable QRS duration* and no high-grade atrioventricular block† in the absence of a permanent pacemaker and; • NYHA class I • LVEF > 30% Otherwise disqualified
Aortic regurgitation (treated with SAVR)	May resume driving 1 month after surgery if: • Stable QRS duration* and no high-grade atrioventricular block† in the absence of a permanent pacemaker and; • NYHA class I-III Otherwise disqualified	May resume driving 3 months after surgery if: • Stable QRS duration* and no high-grade atrioventricular block† in the absence of a permanent pacemaker and; • NYHA class I and; • LVEF $\geq$ 30% Otherwise disqualified
Mitral stenosis (treated with SMVR)	May resume driving 1 month after surgery if: • NYHA class I-III Otherwise disqualified	May resume driving 3 months after surgery if: • NYHA class I Otherwise disqualified
Mitral regurgitation (treated with SMVR or repair)	May resume driving 1 month after surgery if: • NYHA class I-III Otherwise disqualified	May resume driving 3 months after surgery if: • NYHA class I and; • LVEF $\geq$ 30% Otherwise disqualified
Tricuspid regurgitation (treated with STVR)	May resume driving 1 month after surgery if: • NYHA class I-III Otherwise disqualified	May resume driving 3 months after surgery if: • NYHA class I and; • LVEF $\geq$ 30% Otherwise disqualified

HF, heart failure; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association; PBMV, percutaneous balloon mitral valvuloplasty; SAVR, surgical aortic valve replacement; SMVR, surgical mitral valve replacement; STVR, surgical tricuspid valve replacement or repair; TAVR, transcatheter aortic valve replacement; TEER, transcatheter edge-to-edge repair; TMVR, transcatheter mitral valve replacement; TTVR, transcatheter tricuspid valve replacement.

*Stable QRS duration: no new bundle branch block and stability of the QRS duration within 10% at 24 hours post-TAVR or aortic valve replacement.

†High-grade atrioventricular block: second-degree type II and third-degree atrioventricular block.

‡Although few data exist on sudden cardiac incapacitation after these procedures, the consensus opinion was that caution was warranted to allow for apropriate recovery from hospitalization, immobilization, sedation, and vascular instrumentation.

therefore recommended only in those who are in the lowest risk subgroup (ie, asymptomatic with no previous episodes of syncope or presyncope, no angina, and no left ventricular dysfunction). Only in this lowest-risk subgroup would the annual risk of sudden death be estimated to be < 1%.

TAVR has become the intervention of choice among older patients with severe calcific aortic stenosis across surgical risk groups. TAVR is now a class 1A recommendation in the American College of Cardiology/American Heart Association valvular heart disease guidelines in patients with severe symptomatic aortic stenosis aged 65 years and older.[35] The primary complications of concern post-TAVR that might limit fitness to drive include access-related complications and postoperative conduction system disease leading to bradyarrhythmias. The low-risk **P**lacement of **Aor**tic Tra**n**scathet**er** Valves **3** (PARTNER-3) trial showed low rates of transfemoral access-related complications, comparable with surgical aortic valve replacement.[36] There remains a paucity of data regarding the optimal management of postoperative conduction abnormalities. The **M**ultidisciplinary, **M**ultimodality, But **M**inimalist Approach to Transfemoral **T**ranscatheter **A**ortic **V**alve **R**eplacement (3MTAVR) study developed a clinical pathway to facilitate safe next-day discharge post-TAVR.[37] In this study, patients were discharged with a new intraventricular conduction delay in the absence of new high-grade atrioventricular (AV) block if the length of the QRS was stable or decreasing after 24 hours. There was a low rate of late heart block requiring permanent pacemaker (0.24%) and the rate of new permanent pacemaker implantation using these criteria for next-day discharge was 5.7%. This pathway is endorsed by the recent 2020 American College of Cardiology expert consensus, which recommends discharge home if there is no new AV block, no new bundle branch block, and no progression of AV block or prolongation of the QRS by $\geq$ 10%.[38] We have, therefore, adapted these 2 criteria for the assessment of fitness to drive because the risk of SCI was < 1% within the first year in several major contemporary randomized controlled trials and registries.[36,39-41]

Aortic regurgitation

Aortic regurgitation is associated with HF and left ventricular dysfunction. Severe HF symptoms, NYHA class IV, are associated with a significant increase in mortality, therefore private driving should be restricted in this population. Because the rates of sudden death, and therefore SCI, have not been reported in patients with aortic regurgitation, commercial driving should only be recommended for those who are asymptomatic with preserved left ventricular function as per expert consensus.

Mitral stenosis

The natural history of asymptomatic or minimally symptomatic mitral stenosis is favourable (> 80% survival at 10 years). Globally, rheumatic mitral valve disease is an important cause of mitral stenosis and subsequent HF.[34] Mortality is usually due to progressive HF, systemic embolism related to concomitant atrial fibrillation, or pulmonary hypertension. SCD in the absence of severe symptoms is rare. For commercial driving, the development of symptoms, pulmonary hypertension, or systemic embolism might result in limitations associated with tasks related to commercial driving.[42]

Mitral and tricuspid regurgitation

Mitral and tricuspid regurgitation might be associated with atrial arrhythmias and HF symptoms. In particular, patients with severe mitral regurgitation in the setting of a flail mitral valve leaflet are also known to be at risk of SCD. Risk factors in these patients include severe symptoms, reduced left ventricular systolic function, and atrial fibrillation.[43] The presence of NYHA class IV HF symptoms is associated with increased risk of mortality and SCD, therefore private driving should be restricted in this population of patients with mitral and tricuspid regurgitation. Commercial driving should only be recommended for those who are asymptomatic with preserved left ventricular function.[44]

Sex-specific recommendations

None of the studies reviewed stratified SCI or SCD according to sex, and therefore no sex-specific recommendations can be made. In all of the studies, most of the population were men, and there remains a paucity of studies on SCI or SCD in women with valvular heart disease.

Sternotomy-based or minimally invasive valve surgery

Although catheter-based valve procedures are increasingly prevalent among patients who require an intervention, conventional surgical procedures remain appropriate for a significant number of patients with valvular heart disease. An analysis from the SWEDEHEART data determined that death from any cardiovascular cause in their series of 33,108 patients who had undergone aortic valve replacement was 10.2% at 5 years, 23.5% at 10 years, 34.9% at 15 years, and 42.8% at 20 years.[45] Only a small proportion of these would be sudden deaths, and much of the data were derived from patients who would not be the beneficiaries of more contemporary concurrent medical therapy. Aside from the short-term implications of recovering from a sternotomy, the determinants of risk of SCI after initial recovery are functional status, conduction system integrity, and LVEF, as is the case for patients with valvular disease treated with catheter-based solutions.

Practical tips:

- Patients with untreated severe symptomatic aortic valve stenosis and regurgitation (NYHA class IV) are disqualified from private driving. For commercial driving, untreated aortic stenosis must be completely asymptomatic (NYHA class I).
- Patents with untreated severe symptomatic mitral valve stenosis and regurgitation and tricuspid valve regurgitation (NYHA class IV) are disqualified from private and commercial driving.
- Patients who have undergone TAVR with a stable QRS duration and no high-grade AV block may resume private driving 1 month after implantation date and commercial driving 3 months after implantation date.
- Unless they remain NYHA class IV, patients who undergo mitral valve or tricuspid valve transcatheter edge-to-edge repair may resume private driving 48 hours after the procedure.

3. HF, Transplantation, LVADs

Question 3: In adult persons living with HF, a LVAD, or heart transplant who are considering driving, what is the risk of death or SCI (including SCD) within 1 year, stratified according to sex, age, and LVEF? In this section, the most frequent marker for SCI is sudden death, and available data allow us to stratify patients on the basis of functional class and EF.

Heart failure

HF, a clinical syndrome with signs and symptoms secondary to structural/functional cardiac abnormalities, pulmonary, and systemic congestion,[46,47] can affect the ability to drive safely (Table 3). Classification of HF is on the basis of LVEF, and categories include HF with reduced EF (HFrEF; LVEF $\leq$ 40%), HF with mildly reduced EF (LVEF 41%-49%), HF with preserved EF (HFpEF; LVEF $\geq$ 50%), and HF with improved EF (EF > 10% increase from a reduced LVEF of $\leq$ 40%).[46,47] Approximately half of all patients with HF have HFpEF.

Mortality associated with HF is attributed to SCI, progressive pump dysfunction, and death from noncardiac causes, the last of which becomes progressively more common as LVEF increases.[48,49] The overall 1-year mortality after diagnosis is between 25% and 40%. The median survival for HF patients is currently 1.7 years for men and 3.2 years for women[48] with an age-adjusted mortality overall of nearly 6% at 1 year and 45% at 5 years.[50] Mortality risk in any given patient is influenced by many factors including treatment of the underlying cause, use of guideline-directed medical therapy, and use of device therapy, including implantable defibrillators for primary and secondary prevention with and without resynchronization.[51] Recent VAs that have occurred in patients with HF affect the fitness to drive risk assessment in the months after the arrhythmic event. Risk of death estimated from randomized clinical trials might not reflect risk in everyday clinical settings because of the stringent eligibility criteria of trials.

HF remains among the most common causes for hospital admission in older adults, with readmission rates of 27% and 36% within 30 and 90 days, respectively,[52] and mortality risk of 15% at 90 days after discharge.[53,54] An important consideration when assessing risk, however, is that SCD in the setting of HF is almost invariably arrhythmic and might be the result of either ischemia-induced or scar-related malignant ventricular arrythmias.[55] In addition, the rates of SCI in patients with HF varies across the EF spectrum,[56] such that similar SCI rates are observed in patients with HF with mildly reduced EF (LVEF $\leq$ 49%; 28%) and HFrEF (LVEF

Table 3. Recommendations for fitness to drive with heart failure, LVAD, and heart transplant

Condition	Private driving	Commercial driving
Heart failure		
NYHA class I	No restriction	Disqualified if EF < 30%
NYHA class II	No restriction	Disqualified if EF < 30%
NYHA class III	No restriction	Disqualified
NYHA class IV	Disqualified	Disqualified
Receiving intermittent outpatient or home inotropes	Disqualified	Disqualified
LVAD	May resume driving if: • At least 2 months postimplant and; • NYHA class I-II Otherwise disqualified	Disqualified
Heart transplant	May resume driving if: • At least 6 weeks after discharge and; • NYHA class I or II and; • Receiving stable immunosuppression therapy and; • Undergoing annual reassessment Otherwise disqualified	May resume driving if: • At least 6 months after discharge and; • NYHA class I and; • EF ≥ 50% and; • Undergoing annual reassessment which includes testing to rule out active ischemia Otherwise disqualified

EF, ejection fraction; LVAD, left ventricular assist device; NYHA, New York Heart Association.

≤ 40%; 34%) but SCI rates are substantially lower in patients with HFpEF (LVEF 50%-59%; 20%).[56]

Severity of symptom burden on the basis of NYHA functional class can also be used to estimate risk. For example, patients who are NYHA class IV with HFrEF and being treated with infusions of inotropes (either intermittent outpatient or home inotropes) have at least a 0.5%-2% mortality per week and are therefore medically unfit to drive.[57-59] Patients who have NYHA class IV symptoms and HFrEF but not treated with inotropes have a mortality of 35% at 3 months[60] and a risk of SCD of 50%. Fitness to drive becomes less clear in the patient with NYHA class IV symptoms who improves to NYHA class III. One-year mortality in patients with HFrEF and NYHA class III symptoms is estimated at 12%-27%, with 30%-50% of these related to sudden deaths[60]; this poses an acceptable risk for private driving (acceptable SCI annual risk in private drivers is 22%), but not for commercial driving (acceptable SCI annual risk of 1%).

Patients with NYHA class II symptoms are at lower risk overall but still have a proportionally higher risk of SCD and less risk of progressive HF. On the basis of the accumulated evidence from **H**eart **F**ailure: **A** **C**ontrolled **T**rial **I**nvestigating **O**utcomes of Exercise Trai**n**ing (HF-ACTION),[61] **T**reatment **o**f **P**reserved **C**ardiac Function Heart Failure With an **A**ldosterone An**t**agonist (TOPCAT),[62] and **Guid**ing **E**vidence-Based Therapy Using Biomarker **I**ntensified **T**reatment in Heart Failure (GUIDE-IT),[63] the annual risk of mortality in the treatment groups was 7%-15%.[64] These risks are within the acceptable limit of annual SCI of 22% and as such patients who are NYHA class II are fit for driving a private motor vehicle, but again this risk would be too high to allow commercial driving.

Patients with NYHA class I symptoms are at the lowest risk for an incapacitating cardiac event and are therefore acceptable for private driving. For those patients with an EF ≤ 30% there is a 10% annual risk of death and a 5% annual risk of SCD. Commercial driving therefore is not recommended for patients with an EF < 30%, even if they are asymptomatic, because the acceptable SCI annual risk for commercial drivers has been set at 1%.

Guidance for patients with HF and ICDs is provided in the *Rhythm and Devices: CIEDs, Bradyarrhythmias, and Tachyarrhythmias* section.

Practical tips:

- Commercial drivers with HFrEF and LVEF < 30% and/or NYHA class III-IV are disqualified from driving.
- Private drivers with HF and NYHA class IV symptoms are disqualified from driving.

Cardiac transplantation

Although there is concern regarding transplant rejection in heart transplant recipients, particularly early in the post-transplant period, this decreases with time from transplantation. Of greater concern is the risk of SCD, which is associated with 10% of all post-transplant deaths and is thought to be a result of cardiac allograft vasculopathy.[65,66] Little is known about the time course between the development of cardiac allograft vasculopathy and SCD.

Practical issues such as sternal healing must also be considered. Therefore, transplant patients should not drive privately until at 6 weeks post transplant. This should be evaluated on an individual basis, however, because many patients might remain deconditioned at the 6-week mark post transplant and might still be unfit to drive.

Commercial driving risk assessment should be determined on the basis of cardiac function and functional class. Patients who are beyond 6 months from the time of their transplant, receiving stable immunotherapy, with a LVEF ≥ 50% and NYHA classification of I are acceptable for commercial driving. For patients more than 5 years after transplantation, there is an increasing risk of underlying cardiac graft vasculopathy and most transplant centres perform surveillance annually with annual exercise testing, pharmacologic stress imaging for ischemia, or coronary angiography. These patients

continue to be within acceptable risk for commercial driving if there is no evidence of active ischemia, with a LVEF $\geq$ 50% and NYHA classification of I.

When the risk of early complications and primary graft dysfunction has passed, heart transplantation offers a median survival of $>$ 10 years, often with preservation of quality of life. As noted, the risk of progressive cardiac graft vasculopathy increases after 5 years, and remains the leading cause of eventual graft dysfunction and recurrent HF. As such, the guidelines for driving and travel for HF patients with NYHA classification of III or greater symptom burden could be applicable to patients developing late graft dysfunction.

Practical tips:

- Post heart transplantation, patients should be assessed on an individual basis with regard to determining fitness to drive.
- For commercial driving, patients should be beyond 6 months, NYHA class I with LVEF $\geq$ 50% and assessed annually.

LVADs

In 2012, the CCS published a focused position statement on fitness to drive for those with LVADs[5] on the basis of emerging evidence of sufficiently low SCI rates and an increasing proportion of patients receiving LVADs for destination therapy. An increasing number of patients are undergoing implantation with LVADs for the treatment of advanced HF to improve their functional capacity and quality of life. In fact, 80% of patients are classified as NYHA class I or II at 6 months after implantation.[67-70] In addition, improvement in device technology and the use of LVAD support for destination therapy results in the potential for longer duration of LVAD support, including some now with $>$ 10 years of device therapy.

In 2 studies in which patients with LVADs were surveyed, most patients believed that their self-perceived safety of driving was adequate.[71,72] However, a small percentage of patients (16%) experience minor device alarms (battery or suction alarms) while driving. In 1 study of 94 patients, 1 patient experienced a syncopal event.[72] In addition, 16% of LVAD patients indicated that the LVAD moderately/severely affected their concentration whereas 28% indicated that their ability to drive was moderately/severely affected.[72] These data suggest that driving might be reasonably safe for stable patients, although more evidence is required to make definitive recommendations.

Patients with an LVAD have the potential to experience VAs (ventricular tachycardia [VT] or ventricular fibrillation [VF]) and therefore will typically also have an implantable cardioverter defibrillator. However, because of the nature of LVAD support, they are at much lower risk for syncope or even sudden death.

The recent **Inte**ragency **R**egistry for **M**echanically **A**ssisted **C**irculatory **S**upport (INTERMACS) registry (2012-2018) of $>$ 16,000 patients who underwent continuous flow LVAD support documented 1-, 3-, and 5-year mortality rates were 18%, 39%, and 58%, respectively.[73] Adverse events in those with continuous flow LVADs included stroke, gastrointestinal bleeding, device malfunction, and infection. Most of these events are highly unlikely to result in sudden incapacitation. Cardiac and device failure are generally slow and progressive, and death in most patients with LVADs is not sudden in nature. Device failures are almost exclusively related to the external portion of the drive line that do not result in sudden failure of the LVAD. Even abrupt loss of power to the pump does not result in SCI, but rather HF, unless the aortic valve has been oversewn. These data include the first 2 months postimplantation when patients should be excluded from driving, so the risk would be even lower for those beyond the 2-month mark. On the basis of these data, at most between 0.35 and 1.5 events that might result in sudden incapacitation could occur per patient-year.

Thus, patients with LVADs would appear, even in worst-case scenario calculations, to have a $<$ 22% annual risk of SCI, making them eligible for private driving. However, they still have a rate of SCI that is $>$ 1%, which falls short of the standard required for commercial driving. We recommend that patients who are stable with LVAD support (NYHA class I-II), discharged from hospital, and are at least 2 months postimplantation be allowed to drive a private motor vehicle.

Fitness to drive recommendations for patients with LVAD support and cardiac transplant are provided in Table 3.

Practical tips:

- Patients with LVADs are typically deconditioned at the time of the placement of the LVAD. Practical consideration for fitness to drive should include NYHA I-II symptoms in addition to exercise tolerance. We recommend that patients are able to walk for a minimum of 30 minutes as a marker of improved level of fitness.
- Patients with LVADs are disqualified from commercial driving.

Values and preferences:

- High value is placed on defining the clinical status and symptom burden of the patient with HF as defined according to NYHA class.
- Assessing the mortality risk is multifactorial and can be modified with use of guideline-directed medical therapy, and device therapy such as ICDs and LVADs.
- Other important considerations that influence risk include recent sustained VAs, and new hospitalizations and/or readmissions to hospital as a predictor of increased risk of events, including SCD.
- Preference is given to patients with NYHA classification of I and II and LVEF $\geq$ 30% to drive commercial vehicles. Patients with NYHA III-IV symptoms or with an LVAD should not drive commercial vehicles.

4. Inherited Arrhythmia Syndromes and Cardiomyopathies

Question 4: In persons with inherited cardiac conditions, diagnosed with or at risk for an inherited cardiac condition who are considering driving, what is the rate of SCD, syncope, or impaired consciousness (these conditions serve as the surrogate for SCI in this section)?

Inherited heart diseases are common causes of SCD in young individuals and are similarly associated with risk of syncope. They are globally divided into genetic cardiomyopathies and primary electrical heart diseases. Cardiomyopathies associated with a risk of SCD include hypertrophic cardiomyopathy (HCM) and arrhythmogenic cardiomyopathy (ACM). The most common primary electrical diseases include Brugada syndrome and long QT syndrome.

Fitness to drive for patients with this diverse group of diseases is determined according to the risk of VA events potentially causing impairment of consciousness or SCD (Table 4). This risk highly depends on the nature and severity

Table 4. Recommendations for fitness to drive for patients with inherited arrhythmias and cardiomyopathies

Condition	Private driving	Commercial driving
Brugada syndrome		
Spontaneous type 1, asymptomatic	No restriction	No restriction (after expert evaluation)
Provoked type 1, asymptomatic	No restriction	No restriction
Symptomatic, previous syncope*	No restriction	Disqualified (consider resuming ≥ 3 years with expert evaluation†)
Symptomatic, previous CA	May resume driving after 3 months	Disqualified
Long QT syndrome		
Asymptomatic, QTc < 500 msec	No restriction	No restriction if adherent to recommended β-blockers
Asymptomatic, high-risk features (QTc > 500 with long QT type 2 or 3), receiving recommended β-blockers	No restriction‡	Disqualified, but can be considered for resumption (with expert opinion) after 6 months if adherent to recommended β-blockers
Previous syncope*, receiving β-blockers§	May resume driving after 3 months	Disqualified, but can be considered for resumption after 12 months if adherent to recommended β-blockers
Previous CA, receiving β-blockers§	May resume driving after 3 months	Disqualified (consider resuming ≥ 5 years with expert evaluation†)
ARVC		
Definitive diagnosis‖ No previous syncope*	No restriction‡	Disqualified (unless stable and expert evaluation determines otherwise†)
Previous syncope* and stable while receiving appropriate therapy	May resume driving after 3 months‡	Disqualified (consider resuming at ≥ 3 years with expert evaluation†)
Previous sustained VA event and stable while receiving appropriate therapy	May resume driving after 3 months	Disqualified (consider resume at ≥ 5 years with expert evaluation†)
No definite diagnosis: variant carriers, family members with no definite ARVC, possible or borderline diagnosis	No restriction	No restriction
Lamin cardiomyopathy		
Previous sustained VA stable while receiving appropriate therapy	May resume driving after 3 months	Disqualified (consider resume at ≥ 5 years with expert evaluation†)
No high-risk features	No restriction	No restriction
High-risk features (≥ 2 of: LVEF < 45%, male sex, NSVT and nonmissense variants)	No restriction‡	Disqualified
Other arrhythmogenic cardiomyopathies		
Previous sustained VA event and stable while receiving appropriate therapy	May resume driving after 3 months	Disqualified (consider resume at ≥ 5 years with expert evaluation†)
Low risk of VA (< 1% annually) according to expert opinion	No restriction	No restriction
Higher risk of VA according to expert opinion	No restriction if annual risk of VA < 22% Driving prohibited if annual risk of VA ≥ 22%	Driving prohibited if annual risk of VA ≥ 1%
Hypertrophic cardiomyopathy		
Previous sustained VA event	May resume driving after 3 months	Disqualified (consider resuming at ≥ 5 years with expert evaluation†)
No high-risk features	No restriction	No restriction
High-risk features: any of wall thickness ≥ 30 mm, syncope,* otherwise unexplained systolic dysfunction (LVEF < 50%), and presence of an apical aneurysm or a calculated risk of VA > 6% in 5 years	If syncope, may resume driving after 3 months. If asymptomatic, no restriction‡	Disqualified (consider resuming at ≥ 3 years with expert evaluation† and after the age of 60 years)

With respect to modern ICD programming to delay interventions, recommendations are not influenced by the presence of an ICD, regardless of primary or secondary prevention indication for implant.

ARVC, arrhythmogenic right ventricular cardiomyopathy; CA, cardiac arrest; ICD, implantable cardioverter defibrillator; LVEF, left ventricular ejection fraction; NSVT, nonsustained ventricular tachycardia; VA, ventricular arrhythmia.

* Syncope presumed to be arrhythmic.

† If risk of impairment of consciousness is considered < 1% per year on the basis of expert opinion.

‡ If ICD implanted, refer to the appropriate section of the guidelines.

§ If β-blockers are recommended. Exceptions can exist in patients with a previous left cardiac sympathetic denervation.

‖ In case a patient with a borderline diagnosis has a syncopal or sustained VA event deemed to be caused by ARVC after expert evaluation, the same recommendation as for patients with definite diagnosis should be followed.

of the condition. The risk of new onset or recurrent atrial or VAs and related effect on fitness to drive is highly variable, dependent on the underlying condition and its severity, with practical online risk calculators available for ACM and HCM, and numerous references on risk predictors for the remaining conditions, often termed "channelopathies." The risk is primarily driven by symptomatic status, complimented by the severity of the phenotype, with variable input from genetic and family parameters, and sex.

Because of the lack of large-scale, detailed driving-specific data in this realm of uncommon conditions, the clinician is often faced with potential exceptions or patient nuances provided in the recommendation tables and must draw on judgement and updated evidence on risk of incapacitation to guide decision-making. Notwithstanding the language and recommendations in the guidance recommendations, the overarching precedent of accepting a $< 1\%$ 1-year risk of incapacitation represents a guiding principle that is reasonable with input from an expert, typically in a multidisciplinary clinic. This 1% standard has been upheld across this document, on the basis of accepted precedent in the 2003 guidelines and its predecessors.

Brugada syndrome

Brugada syndrome is an inherited primary electrical heart disease characterized according to a specific electrocardiogram (ECG) pattern. The diagnosis relies on the presence of the type 1 Brugada ECG pattern, either spontaneously or when challenged with a sodium channel blocker, in ≥ 1 of leads V_1 or V_2 positioned in the standard position or in higher positions. Type 2 Brugada ECG pattern is nondiagnostic for Brugada syndrome, but usually warrants expert diagnostic evaluation.

The risk of SCD with Brugada syndrome is considered low for most patients in contemporary cohorts.[74,75] Patients at the highest risk are those with a previous history of VA events (VT, VF, cardiac arrest) who have an annual risk of recurrence of 5%-10%[75] followed by those with presumed arrhythmic syncope with an annual risk of VA events of 2.5%.[76] Asymptomatic patients with a spontaneous ECG pattern are at higher risk (0.8%-1% per year) than those who only have a sodium channel-induced type 1 pattern (0.35% per year).[75]

Long QT syndrome

Long QT syndrome is characterized according to a prolonged QT interval, which might be accompanied by abnormal T-wave morphology and can cause VA (specifically, torsades de pointes). It is an inherited cardiac channelopathy generally resulting from rare pathogenic variants in ion channel genes.[77] The cornerstone of therapy for patients with long QT syndrome is β-blockers, along with avoidance of QT-prolonging drugs. Breakthrough events are very rare in patients who are adherent to therapy. The highest risk for VA is in those with a history of cardiac arrest, those with recurrent syncope despite use of β-blockers, and in patients with long QT type 2 and long QT type 3 harboring a QTc > 500 ms. In these latter patients, the annual risk is slightly $> 1\%$.[78,79]

Arrhythmogenic cardiomyopathies

Arrhythmogenic cardiomyopathies can be defined as genetically determined cardiomyopathies that are associated with structural heart disease and a preponderance of VAs out of proportion to the degree of ventricular dysfunction. Arrhythmogenic right ventricular cardiomyopathy was the first ACM to be recognized and is the most characterized of these diseases. The diagnosis is reliant on specific criteria last published in 2010.[80] In addition, other specific genes including Lamin, Filamin C, desmin, RNA binding motif protein 20, and sodium voltage-gated channel alpha subunit 5 are associated with a predominant left-sided disease.

Patients with a definite arrhythmogenic right ventricular cardiomyopathy diagnosis are at relatively high risk of VA events (including sustained or ICD-treated VT/VF and [aborted] SCD). Large series report a risk of approximately 5% per year.[81] The risk of all VA events and more specifically of the most rapid subset of them (VT > 250 beats per minute, VF, [aborted] SCD) can be calculated in these patients using risk prediction models (ARVCrisk.com). Conversely, those who do not meet full diagnostic criteria, unaffected desmosomal variant carriers and minimally affected family members very uncommonly have VA events.[82]

Among the other ACM-associated genes, Lamin is the best characterized. Recognizing the risk associated with this specific disease, guidelines and consensus documents make specific recommendations for ICD implantation.[83,84] An ICD should be considered (IIa recommendation) in the presence of ≥ 2 risk factors among the following: LVEF $< 45\%$, male sex, nonsustained VT, and nonmissense variants. A risk calculator also exists specifically for this disease, with an online version available at: https://lmna-risk-vta.fr. The natural history and associated risks of other arrhythmogenic cardiomyopathies have less extensive data and thus fewer recommendations regarding management thresholds.

Hypertrophic cardiomyopathy

HCM is the most prevalent genetic heart disease, which affects at least 1 person in 500,[85] and is one of the most common causes of SCD in the young. Two approaches to risk stratification exist. Although the European Society of Cardiology guidelines recommendation was made on the basis of a risk calculator approach, the American guidelines use a risk factor-based approach. In the European Society of Cardiology guidelines, a calculated risk of VA $> 6\%$ per 5 years warrants consideration of an ICD (IIa recommendation). The following risk factors are considered as stand-alone indications for primary prevention ICD implantation in patients with HCM: wall thickness ≥ 30 mm, truly unexplained recent syncope, otherwise unexplained systolic dysfunction (LVEF $< 50\%$), and presence of an apical aneurysm. Importantly, the risk decreases significantly after the age of 60 years (0.2% per year).[86]

Guidance for patients with ICDs is provided in the *Inherited Arrhythmia Syndromes and Cardiomyopathies* section.

Table 5. Recommendations for fitness to drive for patients with pacemakers

Condition	Private and commercial driving
Transvenous and leadless pacemakers, with previous impaired consciousness or high-grade AV block	Disqualified for 1 week after implantation, after which patient may resume driving
Transvenous and leadless pacemakers, without impaired consciousness or high-grade AV block	No restriction*
Generator change	No restriction*
Upgrade/lead revision	If there is a history of impaired level of consciousness or high-grade AV block, patient is disqualified for 1 week, after which patient may resume driving Otherwise no restriction*

AV, atrioventricular.

*All procedures (including those marked as "no restriction") are subject to driving restrictions relating to appropriate recovery from hospitalization, site of intervention, vascular access, and the anaesthesia provided (ie, general anaesthesia or sedatives).

Practical tips:

- Fitness to drive is primarily determined according to the risk of VA.
- In this subset of patients, the potential for VAs is considered a reasonable surrogate for the risk of SCI.
- The risk of new onset or recurrent arrhythmias and related effect on fitness to drive is highly variable, primarily driven by symptomatic status and the severity of the phenotype.
- Practical online risk calculators are available for ACM and HCM (https://arvcrisk.com, https://doc2do.com/hcm/webHCM.html, https://professional.heart.org/en/guidelines-and-statements/hcm-risk-calculator)
- Asymptomatic or genetically at-risk patients are not restricted from private driving but might be restricted from commercial driving.
- The presence of an ICD does not influence driving eligibility or disqualification.

5. Rhythm and Devices: CIEDs, Bradyarrhythmias, and Tachyarrhythmias

Patients with a history of bradyarrhythmias, tachyarrhythmias, CIED *in situ*, and those who require CIED implantation are at risk for incapacitation, syncope, and impaired consciousness. For example, patients with selected bradyarrhythmias including complete heart block are at high

Table 6. Recommendations for fitness to drive for patients with ICDs*

Condition	Private driving	Commercial driving†
Transvenous ICDs		
Primary prophylaxis	May resume driving 1 week after implantation	Disqualified
Secondary prophylaxis for VF or VT with impaired level of consciousness	May resume driving 3 months after last incapacitating event	Disqualified
Secondary prophylaxis for sustained VT without impaired consciousness	May resume driving 1 week after implantation	Disqualified
Subcutaneous ICD	Same recommendations as primary and secondary prophylaxis transvenous devices	Disqualified
Generator change	No restriction‡	Disqualified
Upgrade/lead revision	May resume driving 1 week after procedure	Disqualified
ICD delivery of therapy§		
Appropriate ICD shock, or any ICD therapy with impaired level of consciousness or otherwise disabling	May resume driving 3 months after event	Disqualified
Appropriate ICD shock, or any ICD therapy without impaired level of consciousness or otherwise disabling	May resume driving 1 week after event	Disqualified
Inappropriate ICD therapies	No restriction	Disqualified
Electrical storm (≥ 3 VT or VF events in 24 hours)	Disqualified for 3-6 months after event, dependent on severity of electrical storm and clinical management. Expert evaluation required to determine eligibility to return to driving	Disqualified

ICD, implantable cardioverter defibrillator; VF, ventricular fibrillation; VT, ventricular tachycardia.

*All recommendations are subject to physician judgement, incorporating patient-specific considerations, and risk factors for arrhythmias and syncope. Furthermore, all recommendations are on the basis of devices with satisfactory operational parameters (ie, normal functionality). In cases of suboptimal capture thresholds and sensing, unusual programming or device functionality, advised restrictions should be at the discretion of the treating physician.

†Drivers with ICDs are disqualified from commercial driving on the basis of their underlying condition (eg, ventricular dysfunction, history of ventricular arrhythmia) rather than the ICD itself.

‡All procedures (including those marked as "no restriction") are subject to driving restrictions relating to appropriate recovery from hospitalization, site of intervention, vascular access, and the anaesthesia provided (ie, general anaesthesia or sedatives).

§Remote monitoring should ideally be provided for all patients who receive ICDs, to ensure that generator and lead malfunctions can be identified early to prevent device system malfunction and mitigate the risk of adverse events while driving.

risk for syncope, and should typically undergo expedited pacemaker implantation. Similarly, patients with tachyarrhythmias such as VT might be at risk for a life-threatening recurrence.

As such, these patients might require a driving restriction because of the increased risk of incapacitation, syncope, or impaired consciousness, particularly early after these incapacitating events and/or before definitive CIED therapy.

In this section, we summarize the evidence of incapacitation, syncope, and/or impaired consciousness in these scenarios and the recommendations for driving restrictions (Tables 5 sand 6).

Cardiac implantable electronic devices

Question 5a: In persons who undergo CIED implantation or procedure, or, with a history of a CIED who are considering driving, what is the rate of SCD, syncope, or impaired consciousness as a marker of SCI?

Individuals with CIEDs can be broadly categorized into patients with permanent pacemakers (including transvenous, epicardial systems, cardiac resynchronization/conduction system pacing, or leadless devices) and ICDs, either transvenous (single, dual, or resynchronization/physiologic) or extravascular types.

Patients with pacemakers. Contemporary literature suggests that patients with permanent pacemakers are at low risk for pacemaker failure. Early cohorts reported failed sensing that occurred in approximately 2% of patients after pacemaker implantation.[87] Although contemporary registries suggest a rate of lead complications that requiring revision within the first month at approximately 2%-3%,[88] the risk of syncope associated with such events remains very low (see *Bradyarrhythmias* section). In a cohort of 507 patients after permanent pacemaker implantation, syncope occurred in 3% of patients at 1 year, and was attributable to orthostatic hypotension (26%), vasovagal syncope (18%), atrial or VAs (17%), and pacemaker or lead malfunction (7%).

Patients who undergo leadless pacemaker implantation appear to be at lower risk of complications, compared with those with transvenous devices. In a systematic review and meta-analysis across 36 studies (12 studies with safety end points), the incidence of device dislodgement and overall 90-day complication rates were 0.00% and 0.46%, respectively.[89]

The historical 1-week private and commercial driving restriction for patients who undergo permanent pacemaker implantation takes into consideration the healing of the incision and potential discomfort and for prevention of inadvertent dislodgement of newly implanted pacemaker leads that would have a clinical effect in patients with previous high-grade or complete AV block or syncope. In addition, excessive arm and activity restrictions can also affect mobility, mental health, and quality of life (Table 5).

Patients with ICDs. Traditionally, driving restrictions in patients with ICDs were because of their underlying risk for malignant VAs. Early studies in patients who presented with VT/VF showed an incidence of recurrent VF, poorly tolerated or unstable VT, syncope, SCD, or ICD shock in 4.2% in the first month, and 1.8% per month between months 2 and 7, and 0.6% per month afterward.

In a recent cohort of 2786 patients with primary and secondary prevention ICDs, the rate of appropriate shock at 1 month was 0.9% and 2.2%, for patients with primary and secondary prevention devices, respectively.[90] Recent Canadian cohorts of patients with primary and secondary prevention ICDs (**D**riving **R**estrictions and **E**arly **A**rrhyth**m**ias in Patients Receiving a Primary-Prevention **I**mplantable **C**ardioverter-**D**efibrillator [DREAM-ICD] and DREAM-ICD II) have also been reported. In 803 patients with primary prevention ICDs, ICD therapies occurred in 0.12% at 1 month and 0.75% at 6 months.[91] In 721 patients with secondary prevention ICDs, the cumulative incidence of appropriate therapies was also very low. Notably, most episodes of recurrent VA occurred within the first 3 months (34%) after device implantation, and decreased over time (11% between months 3 and 6, and 12% between months 6 and 12). The risk of arrhythmic syncope resulting in SCI was 1.8% within the first 3 months and 0.4% in months 4-6 after device implantation.[92]

Together, these 3 contemporary studies support a low rate of VAs and ICD therapies in patients with primary and secondary prevention ICDs. The very low rate of ICD therapies in primary prevention patients has supported a private driving restriction to 1 week after implantation, in line with the permanent pacemaker implantation guidelines (Table 6). In addition, driving recommendations must also take into consideration whether the patient has concomitant cardiac conditions that are limiting (eg, symptomatic HF; Table 3). The low rate of ICD therapies in secondary prevention patients has supported a reduction of the private driving restriction postimplantation. Taking into consideration the risk of harm with most events occurring within the first 3 months (albeit at a very low rate), the private driving restriction has been reduced to 3 months.

Modern ICD programming. Despite a theoretical concern that prolonged detection might result in sustained VAs and syncope, various studies have shown that this is not the case. In the **M**ulticenter **A**utomatic **D**efibrillator **I**mplantation **T**rial-**R**educe **I**nappropriate **T**herapy (MADIT-RIT) study, 1500 patients were randomized to 3 different ICD programming arms; there was no increase in arrhythmogenic or all-cause syncope according to programming arm.[93] In a systematic review and meta-analysis of 6 studies and almost 8000 patients, therapy reduction programming resulted in no increase in syncope.[94] Because ICD therapies might be deployed when the patient is sleeping, it is sometimes difficult to ascertain whether the therapies are disabling or not. Even history of previous therapies might not necessarily be representative of symptoms that the patient might experience each time, therefore not necessarily predictive of whether said therapies would be disabling. Because of this important limitation, and in erring on the side of caution, we recommend that for appropriate ICD shock or any ICD therapy occurring during sleep, driving is prohibited for 3 months.

Contemporary ICD implantation also includes the use of subcutaneous ICD technology, obviating the need for transvenous leads, and potentially reducing lead-related complications. Because there is no anticipated difference in event rates

when transvenous are compared with subcutaneous ICDs, the new recommendations for driving restriction for these devices are largely the same. Specific circumstances might arise when repeated defibrillation threshold testing is performed, with previous studies suggesting a slight increase in SCD in patients who receive defibrillation testing.[95]

Electrical storm. Patients with VA electrical storm require individualized driving restrictions, according to the severity of their clinical presentation, clinical course, and management. A greater risk of adverse events (including mortality) in patients with clustered VAs, compared with other groups has been reported.[96] Similarly, patients with a greater number of arrhythmias per cluster and shorter cluster length are at greater risk for mortality. Clustered arrhythmias terminated with ICD shocks, compared with antitachycardia pacing, are also associated with increased mortality. The risk of VA recurrence might depend on the clinical management, correction of reversible causes or triggers, ablation, and the use of antiarrhythmic therapy.

Generator changes. Studies have shown no differences in arrhythmias or ICD therapies in the 3-6 months before and after device replacement.[97]

Practical tip:

- Patients with VA electrical storm might require more aggressive driving restrictions (compared with the standard 3-month restriction), dependent on the severity of electrical storm and clinical management (ablation and/or antiarrhythmic therapy). Those with clustered arrhythmias, ICD shocks, and a greater number of arrhythmias per cluster/shorter cluster length might require prolonged driving restrictions, at the discretion of the treating physician.

Bradyarrhythmias

Question 5b: In persons with sinus node dysfunction or conduction system disease and a pacemaker who are considering driving, what is the rate of syncope or impaired consciousness as markers of SCI?

For patients with conduction disturbances, there is an important distinction as to whether these findings are isolated (absence of symptoms) or occur in the presence of symptoms (ie, syncope). In the former group, most of such cases are associated with a low risk of syncope. In the latter group (previous syncope), numerous studies have shown high rates of recurrent syncope. As such, determining the private and commercial driving restrictions for these patients is heavily dependent on a thorough history and evaluation of symptoms (Table 7).

Isolated conduction disturbances/electrocardiographic findings. The risk of incident syncope associated with isolated electrocardiographic findings (ie, first-degree AV block, right bundle branch block) is extremely low. In a Framingham study of 7575 participants, the incidence of pacemaker implantation for individuals with first-degree AV block was 140 per 10,000 person-years.[98] This has been reported in similar cohorts of patients with isolated right and left bundle branch blocks, with a very low risk of progression to pacemaker

Table 7. Recommendations for fitness to drive for patients with bradyarrhythmias

Condition	Private and commercial driving*
Sinus node dysfunction	
Sinus node dysfunction without impaired level of consciousness	No restriction
Sinus node dysfunction with impaired level of consciousness (sick sinus syndrome)	Disqualified until appropriate pacemaker therapy
Symptomatic pauses (≥ 5 seconds) during AF (pauses during AF or conversion pauses)	Disqualified until appropriate pacemaker therapy
AV and fascicular block[†]	
Isolated first-degree AV block	No restriction if no impaired level of consciousness[‡]
Isolated RBBB, left anterior fascicular block, or left posterior fascicular block	No restriction if no impaired level of consciousness[‡]
LBBB	No restriction if no impaired level of consciousness[‡]
Bifascicular block	No restriction if no impaired level of consciousness[‡]
Second-degree AV block; Mobitz I	No restriction if no impaired level of consciousness[‡]
First-degree AV block and bifascicular block	No restriction if no impaired level of consciousness[‡]
Second-degree AV block; Mobitz II	Disqualified until appropriate pacemaker therapy
Alternating LBBB and RBBB	Disqualified until appropriate pacemaker therapy
Acquired third-degree AV block	Disqualified until appropriate pacemaker therapy or successful resolution in the case of a reversible cause (eg, inferior STEMI or Lyme carditis)
Congenital third-degree AV block	No restriction if no impaired level of consciousness[‡]

AF, atrial fibrillation; AV, atrioventricular; LBBB, left bundle branch block; RBBB, right bundle branch block; STEMI, ST-elevation myocardial infarction.

* For commercial drivers: we recommend at least annual follow-up with the treating physician to evaluate for symptoms and possible progression of conduction abnormalities.

† There are special considerations when conduction disease is present in patients with certain cardiomyopathies (eg, sarcoidosis) and various inherited conditions (laminopathies, muscular dystrophies). In these patients, driving restriction is at the discretion of the treating physician

‡ For patients with first-degree AV block, LBBB, isolated RBBB, left anterior fascicular block, left posterior fascicular block, bifascicular block, second-degree AV block Mobitz I, first-degree AV block and bifascicular block, and congenital third-degree AV block, no restrictions are required if there is no history of impaired level of consciousness. If there is a history of impaired level of consciousness, driving is disqualified until appropriate cardiac implantable electronic device therapy.

implantation.[99] In a contemporary cohort of 360,000 Dutch patients, the 10-year risk of syncope and third-degree AV block was reported for isolated conduction defects.[100] The highest rates of syncope occurred in individuals with bifascicular block with first-degree AV block, approaching a 25% 10-year risk of syncope.

Low syncope rates with isolated conduction defects translates into a very low risk of SCI in these patients. Therefore, we recommend no restriction across conduction defects as long as patients remain asymptomatic. Excluded from this recommendation are those with documented high-grade AV block, including those with second-degree Mobitz II AV block, alternating bundle branch block, and acquired third-degree AV block.

Conduction disturbances might also arise secondary to surgical or percutaneous interventions, which might have different outcomes and rates of progression dependent on the underlying intervention. Driving restrictions in these cases should be tailored on the basis of the surgical or percutaneous intervention performed and are discussed separately.

Conduction disturbances with syncope. Most studies in patients with a history of syncope and known conduction disturbance have shown an increased rate of recurrent syncope in this population. As such, we have placed specific emphasis on ensuring that patients with conduction disturbances do not have a history of symptoms/syncope. In a recent trial patients 50 years of age and older with bifascicular block, preserved left ventricular function, and ≥ 1 syncope event in the preceding year were randomized to an implantable loop recorder or permanent pacemaker implantation. The primary composite outcome measure comprised cardiovascular death, syncope, bradycardia resulting in pacemaker insertion, and device complications. There were fewer primary outcomes in the pacemaker group but similar recurrent syncope in both groups reflecting other causes of syncope such as vasovagal or orthostatic hypotension, which might occur as well in this population.[101]

In the **S**yncope: **P**acing or **R**ecording **I**n **T**he **L**ater **Y**ears (SPRITELY) trial 115 patients with syncope and bifascicular block were evaluated and 1-year syncope rates of 20% were reported.[102] Similarly, 52 patients with syncope and bundle branch block were enrolled in the **I**nternational **S**tudy on **S**yncope of **U**ncertain **E**tiology-3 (ISSUE-3) study, which and showed 42% syncope recurrence between 3 and 15 months.[103] Similar studies in patients with syncope and documented asystole (≥ 3 seconds) and first-degree AV block have shown a high rate of recurrent syncope or pacemaker implantation.[103,104]

Special considerations: Sarcoidosis and inherited cardiomyopathies. There are special considerations when conduction disease is present in certain inflammatory (including sarcoidosis), infiltrative or inherited cardiomyopathies that might involve the conduction system. For example, patients with sarcoidosis and a history of syncope might have rapidly progressive conduction system disease, and should be restricted from driving until CIED implantation, or an alternate explanation for syncope is determined.[105] Similarly, patients with myotonic dystrophy are at high risk for sudden death and rapidly progressive conduction system disease and hence should be considered for early, appropriate CIED therapy.[106]

Practical tip:

- Patients with specific cardiomyopathies and/or inherited/inflammatory conduction disease (ie, sarcoidosis, myotonic dystrophy, laminopathies) might be at increased risk of sudden death and rapidly progressive conduction disease. The decision and timing of pacemaker/ICD implantation, and the driving restrictions before device implantation, should be at the discretion of the treating physician with expertise in managing such conditions.

Congenital third-degree AV block. Patients with congenital third-degree AV block might have a robust junctional rhythm preventing the onset of typical symptoms associated with acquired complete AV block. Previous studies have suggested that pacemaker implantation is appropriate in patients with symptoms (syncope, presyncope, exercise intolerance) or marked bradycardia with junctional pauses $>$ 3 seconds, complex VAs, or marked QT prolongation.[107]

Practical tip:

- Patients with congenital third-degree AV block might require a driving restriction if they are symptomatic or have evidence of marked bradycardia (junctional pauses $>$ 3 seconds). Decisions surrounding CIED therapy and driving restrictions should be made at the discretion of the treating physician with expertise in congenital heart disease.

Tachyarrhythmias

Question 5c: In persons with a history of SVT or VT, or who undergo an electrophysiological procedure, and are optimally managed with medical therapy and CIEDs (where indicated) and who are considering driving, what is the rate of incapacitation, syncope, or impaired consciousness?

Patients with supraventricular tachycardia (SVT), atrial fibrillation, and atrial flutter might experience syncope or presyncope. In a study of 300 patients with SVT, symptoms included dizziness (47%), near-syncope (50%), and syncope (14%). Women experienced symptoms more frequently than men, and more than half of the patients experienced symptoms while driving.[108] In another study of 589 patients with paroxysmal SVT, 15% of patients experienced syncope or near-syncope during at least 1 episode of SVT.[109] As such, the recommendations for private and commercial driving for patients with SVT are primarily dependent on satisfactory control in patients with a history of syncope or near-syncope (Table 8).

The risk of iatrogenic injury to the conduction system or AV block in patients who undergo catheter ablation is low. Although early studies reported AV node injury requiring pacemaker implantation in up to 2.3% of patients who underwent AV nodal reentry ablation, contemporary multicentre

Table 8. Recommendations for fitness to drive for patients with tachyarrhythmias

Condition	Private driving	Commercial driving
Ventricular arrhythmias*		
VF (no reversible cause)	May resume driving 3 months after index event	Disqualified
VT/VF due to a reversible cause†	Disqualified until/unless successful treatment of underlying condition	
Hemodynamically unstable VT or VT with impaired level of consciousness	May resume driving 3 months after event	Disqualified
Sustained VT with structural heart disease without impaired level of consciousness (in patients without an ICD)‡	May resume driving 3 months after event	Disqualified
Sustained VT§ with structurally normal heart (ie, idiopathic VT) without impaired level of consciousness	May resume driving 1 week after event, and with satisfactory control	Disqualified
SVT, AF/AFL		
SVT/AF/AFL with impaired level of consciousness	Disqualified until satisfactory control	
SVT/AF/AFL without impaired level of consciousness	No restriction‖	
After electrophysiology study or catheter ablation procedure	May resume driving 48 hours after procedure if no new conduction disturbance, dysrhythmias, or exacerbation of underlying condition†	

AF, atrial fibrillation; AFL, atrial flutter; ICD, implantable cardioverter defibrillator; SVT, supraventricular tachycardia; VF, ventricular fibrillation; VT, ventricular tachycardia.

*All patients should receive ICD implantation whenever indicated (ie, VT/VF with no reversible cause, hemodynamically unstable VT, or VT with impaired consciousness).

†Examples of reversible causes of VT/VF include, but are not limited to, VF within 24 hours of myocardial infarction, VF during coronary angiography, VF with electrocution, and VF secondary to drug toxicity. Reversible-cause VF recommendations over-rule the VF (no reversible cause) recommendations if the reversible cause is treated successfully and the VF does not recur.

‡In patients with an ICD present, refer to ICD recommendations.

§All procedures (including those marked as "no restriction") are subject to driving restrictions related to apropriate recovery from hospitalization, site of intervention, vascular access, and the anaesthesia provided (ie, general anaesthesia or sedatives).

‖Sustained VT is VT that lasts for > 30 seconds and/or results in hemodynamic compromise within 30 seconds.

studies have shown a much lower rate of AV block (approximately 0.2%-0.4%). Case series have similarly reported a low rate of AV block with ablation of para-Hisian accessory pathways, particularly with the use of various strategies to avoid inadvertent AV node injury (eg, focal cryotherapy ablation).[110-114] Because of the rare occurrence of conduction system injury, the treating physician should manage such patients on an individual basis.

Practical tips:

- Patients with SVT, atrial fibrillation, or atrial flutter with impaired consciousness may drive after satisfactory clinical control of their arrhythmia, at the discretion of the treating physician.
- Women might experience symptoms associated with SVT more frequently than men.

6. Syncope

Syncope is a common condition (lifetime risk > 35%) that affects men and women equally and comprises approximately 1% of all presentations to the emergency department.[115,116] The underlying mechanism is important because it might predict future events. Syncope can be categorized as either reflex-mediated (carotid sinus syndrome, situational syncope, and vasovagal), orthostatic (primary or secondary autonomic dysfunction), and cardiac (tachyarrhythmia, bradyarrhythmia, valvular, or obstructive pathologies).

Question 6: In persons who have experienced at least 1 syncopal episode, who are considering driving, what is the risk of motor vehicle accidents (MVAs), syncope while driving, or injuries or fatalities as a result of motor vehicle collisions?

Societal tolerance

The preceding CCS guidance documents[3,4] include recommendations on the basis on a calculated societal risk tolerance of < 1/20,000 or 0.005% per year for a risk of serious injury or death due to a syncope event causing an MVA. This led to a modelled target of a societal risk tolerance of < 1% per year for a risk of syncope while driving. These assumptions were on the basis of Ontario driving data in the 1980s. Although the standard acceptable risk for cardiac patients appears to have stood the test of time insofar as its ongoing acceptance by provincial regulatory bodies in Canada, it is less clear that this standard represents society's "acceptable" risk for MVAs (from any cause) across a broad range of noncardiac medical or other circumstances. This is drawn from societal acceptance of current rates of MVA in the general population. Large, governmental data sets from the United Kingdom and Canada from 2009-2013 and retrieved from the internet showed a mean risk of serious injury or death due to syncope while driving to be 0.067% in the general population (Table 9). Similarly, data from a large group health plan in Washington state in 1987-1988[117] showed that in individuals older than 65 years that the risk of serious injury due to an MVA was 0.08%. The estimate in all of the United States was > 0.013%. The unweighted mean average of these data is 0.075% per year, 15-fold higher than the risk tolerance assumed by the CCS in its previous documents.[3,4]

Table 9. Recommendations for fitness to drive for patients who experience syncope

Condition	Private driving	Commercial driving
Single episode of typical vasovagal syncope	No restriction	
Recurrent (within 12 months) vasovagal syncope	No restriction	
Syncope with a reversible cause or treated (eg, orthostatic, hemorrhage, dehydration)	May resume driving after 1 week	May resume driving after 1 month
Situational syncope with avoidable trigger (eg, micturition syncope, defecation syncope)	May resume driving after 1 week	May resume driving after 1 month
Single episode of unexplained syncope	May resume driving after 1 week	May resume driving after 12 months
Recurrent episode of unexplained syncope (within 12 months)	May resume driving after 3 months	May resume driving after 12 months
Syncope due to documented tachyarrhythmia, or inducible tachyarrhythmia at electrophysiology study (overlap with *Rhythm and Devices: CIEDs, Bradyarrhythmias, and Tachyarrhythmias* section)	Refer to *Rhythm and Devices: CIEDs, Bradyarrhythmias, and Tachyarrhythmias* section	
Diagnosed and treated cause (eg, permanent pacemaker for bradycardia; overlap with *Rhythm and Devices: CIEDs, Bradyarrhythmias, and Tachyarrhythmias* section)	Refer to *Rhythm and Devices: CIEDs, Bradyarrhythmias, and Tachyarrhythmias* section	

CIED, cardiac implantable electronic device.

The national yearly population risks of an MVA in the same period (Table 10) in Canada,[118] the United States,[118] the United Kingdom,[118] and Denmark[119] were 0.56%, 2.29%, 0.49%, and 1.21%, respectively. The mean was 1.14% per year, which can be estimated to be society's risk tolerance for driving. This is similar to the past and current CCS guideline risk tolerance for a syncopal episode while driving (< 1% per year). Fitness to drive recommendations in the setting of syncope are summarized in Table 9.

Syncope and MVAs

The results of all studies are weakened by 3 problems. First, syncope is a symptom, not a disease. Patients with a cardiac or other medical cause of syncope should not be included in risk models, and this can happen because of administrative coding. This is on the basis of the assumption that when a diagnosis is made, appropriate interventions will be put in place and the statistical risk shifts to the underlying diagnosis. This leaves vasovagal syncope, related disorders, and heretofore undiagnosed syncope to consider.

Second, all studies reported few hard outcomes, whether they be MVAs due to syncope or serious injuries due to syncope-associated MVAs. Third, many studies report retrospective data preceding medical assessment, and these likely do not reflect the prospective risk after assessment.

The most focused, rigourously collected data are from the **P**revention **o**f **S**yncope **T**rial (specifically, POST trials 1 and 2), which included 418 patients with 3 or more lifetime vasovagal syncopal episodes.[118] These individuals were high-risk patients, with an average of 10 lifetime syncopal episodes and a median of 3 syncopal episodes in the preceding year. The risk of syncopal episodes while driving was 0.62% per driver-year and there was no serious injury detected. The risk of serious harm was estimated to be < 0.0035% per driver-year. This is a population in whom approximately 40% fainted in the year after study entry, and many had recurrent episodes of syncope.

In 4 clinical or administrative studies[118,120-122] of patients with syncope the yearly likelihood of fainting while driving (Table 9) was 0.62%, 0.33%, 0%, and 1% (mean 0.32%). In 6 clinical or administrative studies of patients with

Table 10. Estimates of motor vehicle accidents in the general population and syncope cohorts

Source	Population	Driver syncope per driver-year, %	MVA per year, %	Serious injury and death per year, %
All population cohorts				
Denmark 2016[6]	Citizens	N/S	1.21	N/S
Canada 2012[118]	Citizens	N/S	0.56	0.053
United States 2009[118]	Citizens	N/S	2.29	> 0.013
United Kingdom 2013[118]	Citizens	N/S	0.52	0.082
Washington State 1994[117]	Insured health care, age older than 65 years	N/S	N/S	0.08
Mean				0.075
CCS guidelines[4]	Population		< 1	< 0.005
Syncope cohorts				
Canada 2016[118]	Vasovagal syncope	0.62	0.62	0
Italy 2012[121]	Syncope	0	0	0
Alberta 1995[120]	Vasovagal syncope	0.33	0.26	0
Germany 2003[122]	Syncope	1.0	0	0
Portugal 2016[123]	Syncope	N/S	1.06	N/S
Denmark 2016[119]	Syncope	N/S	2.2	0.007
Mean			0.69	0.0015
CCS Guidelines[3,4]	Sudden incapacitation		< 1	< 0.005

CCS, Canadian Cardiovascular Society; MVA, motor vehicle accident; N/S, not significant.

syncope[118-123] the yearly likelihood of fainting while driving causing an MVA was 0.62%, 0%, 0.26%, 0%, 1.06%, and 2.2% (mean 0.69%). In 5 clinical or administrative studies of patients with syncope[118-123] the yearly risk of a syncope-associated MVA causing serious injury or death was 0%, 0%, 0%, 0%, and 0.007% (mean 0.0015%).

Overall, the compiled new and old data on the risk of motor vehicle collisions in patients with syncope in conjunction with societal tolerance for the risk of motor vehicle collisions suggest we reduce the driving restrictions for these patient populations in low-risk private vehicles. The mean yearly risk of serious injury or death due to a syncope-associated MVA after assessment is 0.0015%, 50-fold less than the societally tolerated risk of 0.075% and the historical CCS benchmark of $< 0.005\%$.[3,4]

Practical tips:

- Syncope as a symptom can be the result of a wide range of underlying cardiovascular pathology, associated with a wide spectrum of risk for recurrent episodes. This highlights the importance of appropriately investigating patients with syncope, to determine the underlying etiology.
- Patients with vasovagal syncope, even recurrent episodes, show a very low risk of episodes while driving, negating the need for driving restrictions.

7. Congenital Heart Disease/Cyanotic Heart Disease

Question 7: In persons with congenital heart disease or associated conditions with possible requirements for oxygen therapy who are considering driving, what is the incremental risk of SCI posed by the presence of cyanosis, separate and apart from the restrictions required by the hemodynamic, structural, and electrical consequences of these conditions?

Congenital heart diseases comprise a variety of entities as well as clinical manifestations. These manifestations include HF, valvular problems, and rhythm disorders, many of which will require implantation of a device. Any driving restrictions on this patient population will therefore more likely be a result of these manifestations or complications. For this reason, the fitness to drive of these patients should be addressed by consulting the relevant sections of this document.

Cyanosis in patients with congenital heart disease presents a different challenge and is secondary to right to left shunting of unoxygenated blood, not poor alveolar oxygen tension. These patients have chronic oxygen desaturation and developed adaptations with a rightward shift of the oxygen-hemoglobin dissociation curve. This shift does not affect oxygen binding in the lungs but favours oxygen release at the tissue level.

Patients with cyanosis and Eisenmenger syndrome can require supplemental oxygen with advanced NYHA functional class (III and IV), but there are no specific evidence-based analyses regarding their fitness to drive. Existing data for supplemental oxygen exists in the field of chronic obstructive pulmonary disease and hypoxia, but this is of limited applicability in the congenital heart disease population.

As such, there are limited restrictions to driving, and each patient should be assessed according to the related comorbidities and complications related to their underlying condition (Table 11).

Practical tips:

- Patients with complex (corrected or uncorrected) congenital heart disease should discuss their fitness to drive with a practitioner with expertise in the field.
- Patients with supplemental oxygen requirements need to be carefully assessed, possibly with the help of respiratory medicine specialists, with regard to their fitness to drive. If applicable, local restrictions concerning the use of in-vehicle oxygen delivery systems need to be followed.

Table 11. Recommendations for fitness to drive for patients with cyanotic heart disease/Eisenmenger syndrome

Condition	Private driving	Commercial driving
Cyanotic heart disease/Eisenmenger syndrome	No restrictions unless other limiting conditions are present Expert individual risk assessment recommended	

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All research reported in the current article adheres to the relevant ethical guidelines.

Patient Consent

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