Travelling with heart failure: risk assessment and practical recommendations

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Abstract | Patients with heart failure are at a higher risk of cardiovascular events compared with the general population, particularly during domestic or international travel. Patients with heart failure should adhere to specific recommendations during travel to lower their risk of developing heart failure symptoms. In this Review, we aim to provide clinicians with a set of guidelines for patients with heart failure embarking on national or international travel. Considerations when choosing a travel destination include travel distance and time, the season upon arrival, air pollution levels, jet lag and altitude level because all these factors can increase the risk of symptom development in patients with heart failure. In particular, volume depletion is of major concern while travelling given that it can contribute to worsening heart failure symptoms. Pre-travel risk assessment should be performed by a clinician 4–6 weeks before departure, and patients should receive advice on potential travel-related illness and on strategies to prevent volume depletion. Oxygen supplementation might be useful for patients who are very symptomatic. Upon arrival at the destination, potential drug-induced photosensitivity (particularly in tropical destinations) and risks associated with the local cuisine require consideration. Special recommendations are needed for patients with cardiac implantable electronic devices or left ventricular assist devices as well as for those who have undergone major cardiac surgery.

Domestic and international travel are associated with increased health risks, with 20–70% of individuals reporting health issues during their travels¹. During international travel, 1–5% of individuals seek medical attention and the rate of death among travellers is 1 in 100,000, with cardiovascular disease being the most frequent cause of death¹. Trauma, particularly from motor vehicle accidents, is another major cause of death while travelling¹. Health-care providers are frequently approached by patients for advice on how to prepare for travel or to determine whether travelling is advisable at all. General practitioners can provide information to healthy individuals but specialist consultation is of benefit for patients with underlying illnesses such as heart failure (HF)². Indeed, many patients with HF intend to travel for business or leisure. Although some guidance has been published³, a systematic overview of recommendations for patients with HF planning to travel is not yet available. In this Review, we aim to provide clinicians with recommendations for preparatory measures before

travel to inform and educate patients with HF. We discuss factors that might increase the risk of HF symptom development, such as local climate, air pollution levels and altitude levels, and provide specific guidance for patients with a cardiac implantable device and those who have undergone major surgery.

Which patients with HF can travel safely?

To date, guidance on travel recommendations for patients with HF is limited. In general, patients with NYHA class I–III HF who are stable should be able to travel safely⁴. However, patients with NYHA class III HF who are planning to travel by air should be advised to consider on-board medical oxygen support. Patients with NYHA class IV should not travel; however, if travel is unavoidable, on-board oxygen and medical assistance should be requested. A patient with an oxygen saturation rate >90% at ground level usually will not require medical oxygen during flight⁵. An overview of whether travelling is advisable for different classes of HF^{6,7} is provided

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Key points

- Patients with heart failure (HF) are recommended to schedule a specialist consultation for pre-travel risk assessment 4–6 weeks before departure.
- Preparation for travel requires special considerations in patients with HF, including the choice of destination, availability of medical resources and strategies to prevent volume depletion.
- Most patients with HF can travel when medically stable; patients with a ground-level oxygen saturation $\leq 90\%$ or those in NYHA class III–IV might need an on-board medical oxygen supply.
- All medication and important documents should be stored in carry-on luggage.
- Volume depletion and dehydration are important considerations requiring meticulous attention with regards to medication adjustment and fluid intake.
- Patients with implantable cardiac devices might require extra time at security checkpoints and additional documents; for some patients, remote monitoring of implantable cardiac devices might be useful.

in BOX 1. An overview of contraindications for air travel in patients with cardiovascular diseases is provided in BOX 2.

Choice of destination

The choice of destination for travel can have important health implications for patients with HF, particularly when travelling abroad. Considerations include the local climate, air pollution levels, altitude levels, the season upon arrival, the distance and time for travelling, jet lag, and vaccines required.

Effects of transitioning climates on HF

Individuals who transition through climates different to the one they reside in (such as someone living in the arctic travelling to a tropical island) are at an increased health risk. In general, people living in warmer regions tend to be most vulnerable to cold weather and,

conversely, those residing in a cold climate are most sensitive to heat⁸. Exposure to extreme heat has been associated with increased morbidity and mortality from heat exhaustion and heat stroke^{9,10}. Maintenance of homeostasis during hot weather requires an increase in cardiac output; heat tolerance is impaired when cardiac output cannot be increased to meet the requirements of heat loss. Numerous medications that are frequently prescribed for individuals with HF can also increase susceptibility to heat stroke, including loop diuretics, serotonergic antidepressants, angiotensin-converting enzyme inhibitors and proton-pump inhibitors^{11–13}. Colder temperatures are less likely to have effects on cardiovascular health but have been associated with increased morbidity among patients with respiratory disease¹⁴. Patients with HF should be advised to choose either spring or autumn for international travel to avoid travelling during extremities in weather and to adjust medications that can contribute to volume depletion. Appropriate clothing is required for the site of departure, the destination and for the journey itself. Given the challenges in contacting a patient's primary care physician if the patient is in a different country or continent, distant travel destinations might only be advisable for patients who are well-informed about their medication regimen, dietary restrictions and exercise limitations.

Endemic diseases

The need for immunization for travel depends on the destination. In general, the status of routine vaccinations, such as the diphtheria, measles–mumps–rubella, pertussis, tetanus and varicella vaccines, should be checked before travelling abroad. For all patients with HF, vaccines are required for pneumococcal disease, influenza and coronavirus disease 2019 (COVID-19). Other destination-dependent vaccines are provided in TABLE 1.

Air pollution and HF

Air pollution can be measured by the air quality index, which integrates measures for the five main air pollutants: ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide and nitrogen dioxide. An air quality index value of 0–50 indicates good air quality, 51–100 indicates moderately polluted air, >100 indicates an unhealthy level of air pollution and >300 designates a hazardous environment¹⁵. Particulate matter (PM) of $\leq 10\mu\text{m}$ (PM_{10}) or $\leq 2.5\mu\text{m}$ ($\text{PM}_{2.5}$) in diameter are linked with increased cardiopulmonary mortality^{16,17} as well as with an increased risk of hospitalization for HF¹⁸ and death¹⁹. The pathophysiological mechanisms underlying this increased risk remain elusive. Accumulating evidence points towards a crucial role of PM-induced systemic oxidative stress²⁰ and endothelial dysfunction²¹ in the development of arterial vasoconstriction and elevated systemic blood pressure²². In addition, PM-induced pulmonary vasoconstriction results from increases in pulmonary and right ventricular diastolic filling pressures, which affect right ventricular performance²². Given that the effects of air pollutants on cardiovascular performance and outcomes can occur within hours or days of exposure²³, patients with HF

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Box 1 | Travel recommendations for patients with heart failure

Chronic stable heart failure

- NYHA class I–II: travel advisable, if patient is stable
- NYHA class III: travel advisable, if patient is stable; consider use of on-board medical oxygen during air travel
- NYHA class IV: travel not advisable; if travel is unavoidable, on-board oxygen and medical assistance are required

Acute heart failure decompensation

- Travel not advisable until at least 6 weeks after discharge and rehabilitation, if patient is stable

Ventricular assist device implantation

- Travel advisable after hospital discharge and rehabilitation, if patient is stable

Heart transplantation

- Not advisable until at least 1 year after transplantation surgery, if patient is stable

Implantable cardioverter–defibrillator or cardiac resynchronization therapy implantation

- Not advisable until at least 2 weeks after discharge, if patient is stable

should be advised to avoid travelling to locations with high levels of air pollution.

Altitude-induced hypoxia and HF

Patients with HF are more susceptible to the physiological changes induced by high altitude exposure than the general population²⁴. During air travel, cabin pressure is required to be no less than the barometric pressure at an altitude of 2,438 m (8,000 ft), which is classified as an intermediate altitude²⁵ (FIG. 1a). Cabin pressures usually remain higher than this altitude, particularly during long-haul flights²⁶. Travel to high altitude locations that are >2,500 m above sea level triggers physiological acclimatization processes within the cardiocirculatory and pulmonary systems^{27,28} (FIG. 1b). These processes are initiated by a gradual decrease in barometric pressure, which in turn lowers the partial pressure of oxygen in inspired air. Hypobaric hypoxia leads to a fast increase in respiratory rate and tidal volume²⁹, which leads to respiratory alkalosis and hypoxic diuresis³⁰. Hypoxia induces pulmonary vasoconstriction and eventual pulmonary hypertension, an important trigger for high altitude pulmonary oedema³¹. To compensate for the lower arterial oxygen content, heart rate and stroke volume

are increased via activation of the sympathetic nervous system^{26,32–34}. Together, these physiological adaptations limit the exercise capacity of patients with HF and make them prone to cardiac decompensation. However, studies that assessed simulated altitude-induced hypoxia in patients with NYHA class III–IV HF showed that high altitude was not associated with angina, arrhythmia, or ischaemia^{35,36} and that the degree of the reduction of maximum work capacity was dependent on the individual's exercise tolerance at sea level³⁵. The ESC and other professional societies recommend that the assessment of safety of high altitude exposure for patients with HF should depend on their functional capacity (that is, NYHA class) at sea level^{35,37}. Furthermore, certain drugs that are prescribed to patients with HF can further interfere with the physiological adaptation processes at high altitudes. For example, angiotensin-converting enzyme inhibitors and angiotensin receptor blockers can reduce renal erythropoietin production, thereby hampering the compensatory rise in haematocrit mediated by altitude-induced hypoxia³⁸. Therefore, diuretic therapy should be tailored to the individual to account for clinical signs of dehydration (such as through hypoxic diuresis) or fluid gain³⁹. Finally, anaemia reduces oxygen delivery, and muscle loss (present in patients with sarcopenia or cachexia) reduces maximal physical workload and time to fatigue; patients with these conditions in addition to HF need to have special considerations when planning to travel to high altitude locations. To summarize, travel to destinations at an intermediate altitude (~2,000 m) is safe for patients with HF who have good exercise tolerance at sea level.

Seasonal variations and HF

Hospitalizations owing to worsening HF show intriguing seasonality, with a substantial decline during warmer periods and an increase during colder periods^{18,40}, especially in older patients⁴¹. Temperature had the greatest (inverse) correlation with hospitalizations for HF among other causative environmental factors such as humidity, precipitation or irradiation¹⁶. Skin cooling has been shown to increase vascular resistance⁴² and plasma noradrenaline concentration⁴³, which might lead to HF decompensation. Beyond neurohumoural activation and haemodynamic stress, respiratory infections, which peak during the colder months, can precipitate and aggravate HF symptoms⁴¹. Furthermore, vitamin D insufficiency during winter has also been linked to worsening HF⁴⁴. Interestingly, the effect of seasonal variability on health is more prominent in elderly people and winter hospitalization is associated with both poorer short-term and long-term prognosis⁴¹. These observations suggest that patients with more severe HF (and worse prognosis) are prone to decompensation during winter and that these patients and older patients with more advanced disease should be advised to avoid travelling to colder regions. Of note, a study from Norway reported that the Christmas winter period was associated with the highest rates of excess all-cause and cardiovascular deaths⁴⁵. Overall, appropriate clothing and heating strategies need to be carefully selected for optimal stabilization of body core temperatures, vitamin D levels should be measured

Box 2 | Contraindications for air travel in patients with cardiovascular disease

- Myocardial infarction (ST-elevation or non-ST-elevation myocardial infarction) within the previous 2 weeks
- Unstable angina without further diagnostics and treatment
- Percutaneous coronary angioplasty within the previous 2 weeks; in patients who have undergone uncomplicated percutaneous coronary intervention, shorter time frames might be acceptable
- Cardiac surgery or interventional valve therapy within the previous 3 weeks
- NYHA class IV heart failure or any decompensated heart failure
- Untreated arrhythmias (ventricular or supraventricular)
- Eisenmenger syndrome
- Uncontrolled pulmonary artery hypertension
- Pneumothorax (such as after major cardiac surgery)

Table 1 | Travel vaccinations for patients with heart failure^a

Disease	Pathogen and route of transmission	Available vaccines	Target groups
COVID-19	SARS-CoV-2; via respiratory droplets and aerosols (from coughing, sneezing and talking) or surface contact	Numerous vaccines available and in development, including mRNA-based and viral vector-based vaccines	All patients with heart failure
Influenza	Influenza virus; via respiratory droplets or surface contact	Inactivated influenza vaccine, recombinant influenza vaccine and live attenuated influenza vaccine	All patients with heart failure
Pneumococcal disease	<i>Streptococcus pneumoniae</i> ; via respiratory droplets	Inactivated pneumococcal vaccine	All patients with heart failure
Hepatitis A	Hepatitis A virus; highly contagious via person-to-person contact or via contaminated food or drinks	Two monovalent hepatitis A vaccines are available	Travellers to parts of Africa (such as South Africa), Asia (such as Thailand), Central and South America (such as Peru and Bolivia) and Eastern Europe (such as Ukraine)
Hepatitis B	Hepatitis B virus; via percutaneous or mucosal contact with infectious blood or body fluids	Three intramuscular injections of purified recombinant hepatitis B surface antigen	Travellers to intermediate or highly endemic areas
Japanese encephalitis	Japanese encephalitis virus; via <i>Culex</i> mosquitoes	Two doses of inactivated Vero cell-derived vaccine	Travellers to countries in Southeast Asia (such as Indonesia) and the Western Pacific (such as Japan)
Meningococcal disease	<i>Neisseria meningitidis</i> ; via respiratory and throat secretions	Meningococcal conjugate vaccine	Travellers to the meningitis belt in sub-Saharan Africa, particularly during the dry season (December to June); pilgrimage to Mecca in Saudi Arabia
Poliomyelitis	Poliovirus; highly contagious, via faecal–oral and oral–oral route	Three doses of inactivated polio vaccine; oral polio vaccine used in some countries	Travellers to certain countries in Africa (such as Benin) and Asia (such as the Philippines)
Rabies	Lyssaviruses; via saliva of infected animals	Series of three vaccines	Travellers to certain countries in Africa, Asia, and Central and South America who might be in close contact with wild or domestic animals
Typhoid	<i>Salmonella typhi</i> ; via contaminated food or drink	Oral vaccine that is based on the live, attenuated mutant strain given as series of three capsules or a single dose of intramuscular injectable Vi capsular polysaccharide vaccine	Travellers to certain countries in South Asia (such as India) and South America (such as Bolivia and Costa Rica)
Yellow fever	Flavivirus; via <i>Aedes</i> or <i>Haemagogus</i> mosquitoes	Live, weakened form of the virus given as single shot	Travellers to certain countries in Africa (such as Cameroon) and South America (such as Bolivia)

COVID-19, coronavirus disease 2019; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2. ^aDiphtheria, measles–mumps–rubella, pertussis, tetanus and varicella vaccines are recommended routine vaccinations and not detailed here.

before departure and supplemented if required, and vaccines against influenza and pneumococcal disease should be administered⁴⁰ (TABLE 1).

Preparing to travel

Any patient with a history of HF should seek medical consultation before departure, particularly when travelling overseas or when leaving for a long period. Women are generally more likely to seek pre-travel medical advice than men⁴⁶ and are also more likely to have travel-related worries⁴⁷. A cross-sectional national survey found that a low perceived need was among the main causes for avoiding medical care, often because patients expected their illness or symptoms to improve over time⁴⁸. For patients with HF, travel preparation should include a specialist consultation approximately 4–6 weeks before departure. This consultation should follow a structured and sequenced approach, which should involve risk assessment (including an evaluation of medical history and travel itinerary), interventions required

before departure (including physical examination or setting up of remote monitoring for cardiac implantable devices) and focused education on topics such as medications and factors that can lead to volume depletion. For example, the presence of anaemia might cause lightheadedness, angina or loss of consciousness, particularly during flights^{49,50}. Medication regimens should be optimized before departure and patients with iron deficiency should be considered for repletion therapy. Suggestions for topics to cover during this consultation are summarized in BOX 3.

Risk assessment and medication adjustment

As mentioned in the previous section, pre-travel risk assessment should consider the type and duration of travel, the travel destination, and the medical history of the patient. Typical health emergencies that patients with HF might encounter during travel are listed in TABLE 2. Patients should be advised that provision of incomplete medical information during a cardiac emergency might

increase the risk of death. Any accompanying travellers need to know where to find important documents (BOX 4) in case of an emergency. Given the difficulty in obtaining prescription drugs in a different country as well as the different brands of drugs having varying strengths in different countries, extra medication should be brought on the trip. Importantly, some over-the-counter drugs might be legal in the patient's home country but illegal elsewhere (such as certain analgesics).

Remote device monitoring

Remote monitoring is recommended by the ESC and other professional societies for patients with cardiac implantable devices such as pacemakers, implantable cardioverter-defibrillators (ICDs) and implantable cardiac monitors^{51–53}. Most remote monitoring systems use a transmitter (base station) placed in the vicinity

of the implanted device, with information sent via an internet connection to a remote monitoring service. Alternatively, alerts can be activated after events that trigger an immediate remote transmission (for example, after ICD shock, detection of ventricular tachyarrhythmias or signs of lead failure). Given that travelling is usually associated with increased physical activity levels, daily remote monitoring might be useful for the detection of events such as arrhythmias, HF decompensation or device malfunction (BOX 5).

Special considerations

Patients who have undergone recent surgery. Major cardiac surgery ranges from minimally invasive approaches to complete sternotomy. The Canadian Cardiac Society guidelines on air travel recommend that patients with a haemoglobin level <9 g/dl who have undergone coronary

Fig. 1 | Physiological adaptation processes at high altitude involved in cardiac decompensation. **a** | Definitions of height and examples of mountains and cities at different altitudes. Most aircraft fly at approximately 10,000–12,000 m (33,000–42,000 ft) above sea level, with the cabin pressurized to an equivalent of 2,438 m (8,000 ft). **b** | High altitude-induced hypobaric hypoxia leads to an increase in respiratory rate and tidal volume, which promotes respiratory alkalosis, hypoxic diuresis, pulmonary vasoconstriction and, ultimately, pulmonary hypertension and pulmonary oedema. Compensatory mechanisms of this hypoxia include increases in heart rate and stroke volume via activation of the sympathetic nervous system (SNS). Together, these changes can limit exercise capacity and promote cardiac decompensation.

Box 3 | Recommendations for pre-travel assessment

Risk assessment

- Full medical history (current medications, immunization history, history of surgeries or device implantation, immune status, allergies, pregnancy or breast feeding)
- Previous travel experience (particularly to the same destination) or risk tolerance
- Travel itinerary (destination, mode of travel, travel distance, season, air pollution levels, potential jet lag, clothing required and altitude)
- Activities planned (such as adventure sports or hiking, mass gatherings)
- Type of accommodation

In-office interventions

- Physical examination, electrocardiogram tracing, biochemistry analysis (plasma levels of creatinine, ferritin, glucose, glycated haemoglobin, N-terminal pro-B-type natriuretic peptide, potassium, sodium, transferrin saturation, thyroid-stimulating hormone, vitamin D and urea, estimated glomerular filtration rate, and lipid profile and liver function tests), full blood count (to identify potential anaemia), exercise test and/or transthoracic echocardiography
- Set up remote monitoring of implanted devices
- Administration of immunizations (routine vaccines include measles–mumps–rubella, tetanus–diphtheria–pertussis, coronavirus disease 2019 (COVID-19), pneumococcal disease and influenza as well as any destination-specific vaccine that might be needed for diseases such as hepatitis A or yellow fever) or malaria chemoprophylaxis (if required)
- Strategies to prevent or treat traveller's diarrhoea (food and water precautions, oral rehydration, treatment with loperamide and bismuth subsalicylate, and antibiotic self-treatment options for severe diarrhoea)

Focused education before travel

- Medical kit and documents required during travel: personal health kit (medication, device information or medical records), evacuation and health insurance
- Location of medical facilities at destination
- Education on heart failure medication adjustment (to avoid dehydration and volume overload), cardiac device handling, telemonitoring and factors that contribute to volume depletion (excess alcohol, coffee or salt intake; traveller's diarrhoea)
- Patients with a cardiac implanted device should avoid strong electromagnetic fields
- Travel-related illnesses: altitude illness, traveller's thrombosis, bloodborne and sexually transmitted diseases, transportation-associated illnesses, respiratory infections, rabies and other animal-associated illness, and skin conditions and wounds
- Personal protection for vector-borne disease (if at risk)

artery bypass graft surgery should be advised against air travel³⁴; recommendations for travel in patients with HF who have undergone coronary artery bypass graft surgery should perhaps be even more conservative. These patients should be advised not to travel by air until intrathoracic gas resorption is completed given that gas expands when air pressure is reduced with increasing altitude (the Boyle law)⁴. Gas resorption usually takes 3–10 days after surgery. Any air remaining in the pericardial space or in the thoracic cavity can expand by up to 60%, which might be dangerous and painful⁴. Indeed, the Aerospace Medical Association guidelines state that pneumothorax is an absolute contraindication to air travel and advocate an interval of 2–3 weeks before flying after thoracic surgery⁵. Furthermore, patients who have had a recent operation are in a state of increased oxygen consumption owing to the trauma of surgery, possible presence of sepsis and increased adrenergic outflow. A 2017 study compared complication rates between ground and air travel 5–25 days after pulmonary resection⁵⁵. Air travel was as safe as ground travel if the chest tubes were removed after the absence of ongoing air leak and an output <300 ml over 24 hours

combined with adequate pain medication and an active ambulation schedule.

Patients with LVADs. Left ventricular assist devices (LVADs) are increasingly implanted as a bridging strategy while patients wait for heart transplantation or as a permanent therapy for end-stage HF. Patients in either category can travel by air if medically stable and rehabilitation measures have been performed⁵⁶. BOX 6 lists precautions before and during travel for patients with an LVAD.

Considerations while en route**Departure from home**

Patients with HF or ischaemic heart disease need to take extra caution on the way to and from the departure point, such as an airport or train station, given the multitude of stressors: commotion, a delay or any last-minute changes to the train or flight, and lifting of heavy luggage, all of which can increase physical and mental exertion and risk of myocardial ischaemia^{57,58}. As such, travel planning should include estimation of psychological stressors and physical loads as well as a plan for any emergencies (TABLE 2). Pre-planned assistance with luggage or transport by wheelchair at the point of departure might reduce pre-travel stress and physical exhaustion.

Dehydration and fluid intake

Patients with HF are susceptible to volume depletion during travel given that fluid intake, lifestyle and diuretics are tuned precisely to maintain a state of euvoemia⁵⁹ (FIG. 2). A hypovolaemic state adversely affects cardiac and renal function, aggravates HF symptoms, and might interfere with the efficacy of HF medications. Fluid loss, caused by changes in temperature, diet (higher salt intake) or as a consequence of traveller's diarrhoea, might occur during the flight.

On board a plane, the low cabin humidity and cooled air can increase resting ventilatory water losses by approximately 200 ml per hour⁶⁰. In addition, chair rest immobilization for 4 hours can decrease plasma volume by approximately 6% as a result of blood pooling and greater loss of fluid within the interstitial space in the legs⁶⁰. Urinary output is often normal or only slightly reduced⁶¹. Sodium-free, alcoholic or caffeine-containing drinks consumed during the flight can promote diuresis and might further increase fluid loss. Furthermore, arrival to a hot and dry climate can result in loss of fluid through sweating and breathing by up to 1.2 l per day independently of physical activity⁶².

Apart from air travel and a transition in climate, acute diarrhoea is the most common illness in individuals travelling from resource-rich to resource-limited regions of the world^{63,64}. Traveller's diarrhoea usually occurs 4–14 days after arrival and results from bacterial (>90% of cases), viral and parasitic infections⁶⁴. Approximately 10–40% of travellers to high-risk regions in Asia, Africa, and South and Central America experience diarrhoea during their travels⁶⁴. Patients should be educated on food and water safety to prevent ingestion of pathogens. Cardiac dysfunction and HF management and treatment strategies, such as fluid restriction, diuretic therapy

and renin–angiotensin–aldosterone system (RAAS) inhibitors, also increase the risk of diarrhoea-related complications in patients with HF during (temporal) hypovolaemia^{63,64}.

Signs and symptoms of volume depletion and dehydration-associated electrolyte or acid–base disorders include fatigue, exercise intolerance, weight loss, increase in heart rate, muscle cramps, weakness, postural dizziness, abdominal pain, low urine volume, low blood pressure, lethargy and confusion. On the basis of individualized risk assessment, patients should be advised to increase fluid intake by 0.5–1 l per day and to avoid alcohol or excessive coffee consumption during long-haul flights and hot weather. In case of signs and symptoms of volume depletion, therapy with diuretics, mineralocorticoid receptor antagonists and sodium–glucose cotransporter 2 inhibitors should be stopped or reduced for a day or longer until symptoms have resolved and body weight has returned to normal⁶⁵. In case of postural or symptomatic hypotension, therapy with RAAS inhibitors and angiotensin receptor blocker–neprilysin inhibitors should be reduced or discontinued until symptoms have resolved; patients who experience postural or symptomatic hypotension require medical evaluation.

In a hot environment, patients with HF are advised to restrain from strenuous activity to avoid increased fluid loss. In case of uncomplicated traveller's diarrhoea,

patients need to increase fluid intake with oral rehydration solutions and monitor body weight and urinary output to avoid dehydration. Given that patients with HF are at an increased risk of complications, an antimotility agent (loperamide) and an antibiotic (azithromycin or rifaximin) can be prescribed for self-treatment^{63,64}.

Venous thromboembolism

The risk of deep venous thrombosis (DVT) is greatly increased in patients with incident HF according to data from the ARIC cohort⁶⁶ and a systematic review⁶⁷. The term 'economy class syndrome' has been used to describe the venous complications caused by cramped seating conditions⁶⁸. The risk of DVT or pulmonary embolism is increased during travel that is >4 hours in duration, most probably owing to the associated immobility that is a key component of the Virchow triad of hypercoagulability, stasis and endothelial injury. Travelling in general (>4 hours in the preceding 8 weeks) is associated with a twofold increase in the risk of venous thrombosis⁶⁹. This risk seems to be similar regardless of the mode of transportation (airplane, bus or train)⁶⁷. The overall absolute incidence of symptomatic venous thromboembolism (VTE) in healthy individuals within the first month after a flight lasting >4 hours is approximately 1 in 4,600 flights and increases by 18% for each additional 2 hours in flight duration^{2,70}. Importantly, the risk of VTE in individuals with pro-thrombotic risk factors, such as chronic HF,

Table 2 | Typical emergencies in patients with heart failure and preventive measures

Model of travel	Health risk	Risk factors	Preventive measures
Car or bus	Thrombosis and pulmonary embolism	History of thrombosis or active cancer	Frequent rest breaks after walks, sufficient fluid intake and measures to avoid volume depletion, and thromboprophylaxis
Train or plane	Thrombosis and pulmonary embolism	History of thrombosis or active cancer	Frequent walks or stretching of limbs, sufficient fluid intake and measures to avoid volume depletion, and thromboprophylaxis
Any	Myocardial infarction	History of myocardial infarction, CAD, CABG surgery or PCI, and uncontrolled CV risk factors	Timely intake of prescribed medication and immediate medical care if acute chest pain or dyspnoea occurs
Any	Arrhythmias (such as AF, VF and VT)	History of AF, VF or VT, and HFrEF or recurrent syncope of unknown origin	Timely intake of prescribed medication and seek medical advice before departure if heart failure symptoms occur or worsen
Any	Clinically relevant bradycardia	Recurrent syncope of unknown origin or known, clinically relevant bradycardia without pacemaker implantation	Implantation of permanent pacemaker before departure if indicated
Any	Hypertensive crisis	Uncontrolled hypertension	Timely intake of prescribed medication, nitroglycerin spray and check for blood pressure control before departure (for example, ambulatory blood pressure measurement for 24 hours)
Any	Stroke or TIA	History of stroke or TIA, uncontrolled hypertension or uncontrolled CV risk factors	Timely intake of prescribed medication and seek medical advice before departure

AF, atrial fibrillation; CABG, coronary artery bypass graft; CAD, coronary artery disease; CV, cardiovascular; HFrEF, heart failure with reduced ejection fraction; PCI, percutaneous coronary intervention; TIA, transient ischaemic attack; VF, ventricular fibrillation; VT, ventricular tachycardia.

is substantially higher than in the general population. A 2021 meta-analysis found that patients with chronic HF were at an increased risk of VTE (risk ratio 1.57, 95% CI 1.34–1.84)⁷¹. A window seat compared with an aisle seat has been associated with a twofold greater risk of VTE or a sixfold greater risk in individuals with a BMI of >30 kg/m² (REF.⁷²).

Strategies to prevent VTE include appropriate loose clothing, frequent walks, calf muscle exercises, use of elastic compression stockings and adequate hydration⁷³. Leg exercises have been shown to improve popliteal venous flow during prolonged immobility in seated individuals⁷⁴. Furthermore, a systematic review of 11 randomized trials that included 2,906 individuals revealed the benefits of compression stockings (15–30 mmHg) on reducing the incidence of asymptomatic DVT and, with less evidence, of leg oedema⁷⁵.

The evidence for thromboprophylaxis to prevent VTE during travel is very limited. The LONFLIT-3 study⁷⁶ randomly assigned 300 individuals at high risk of flight-related VTE to receive aspirin, enoxaparine (a low-molecular-weight heparin) or no prophylaxis. In total, 4.8% of patients in the control group were diagnosed with asymptomatic DVT compared with 3.6% in the aspirin group and 0% in the enoxaparine group. The authors of this small study concluded that one dose of enoxaparine might be an important option for individuals at high risk of DVT during long-haul flights⁷⁶. Of note, specific studies of thromboprophylaxis during long-haul travel in patients with HF are lacking.

Medical emergencies during air travel

Patients with HF can travel by air if their condition is stable (BOX 1). Commercial airplanes are required to carry basic emergency medical equipment according to regulations of the Federal Aviation Administration (FAA) in the USA and the European Aviation Safety Agency (EASA) in Europe⁷⁷. Commercial aircrafts travelling from Europe to the USA have to meet both FAA and EASA requirements and, thus, must carry on board an external automated defibrillator, a saline infusion system and a bag-valve mask resuscitator⁷⁷.

Data on on-board medical emergencies are sparse owing to the lack of international registries⁷⁸. According to the available data provided by the airline Lufthansa, which contains details on approximately 20,000 on-board medical events from 2000 to 2011, cardiac emergencies accounted for 43% of on-board incidents⁷⁷. Reported medical issues included circulatory collapse, high blood pressure, chest symptoms and dehydration⁴⁷. On-board treatment included blood pressure management in 76% of incidents, drug administration in 54%, oxygen delivery in 48%, blood glucose measurement in 9%, monitoring of oxygen saturation in 6% and use of an automated external defibrillator in 6%⁷⁷.

Considerations at the destination

Dietary considerations

Dietary intake of fluids, sodium, potassium and alcohol during travel should be guided by current ESC recommendations for the management of patients with HF^{3,79}. According to the guidelines, fluid restriction of

Box 4 | Medication and documents required during travel

- Sufficient medication for the whole journey (consider bringing extra drugs in case of unforeseen delays in returning home)
- Medication to be kept in carry-on luggage for flights (in case of loss of luggage or emergency)
- Photocopy of last prescription
- Insurance card
- Patient identification card
- List of diagnosed health conditions and prescribed medicines
- Last discharge letter from hospital
- Device interrogation print-out
- List of names and phone numbers of cardiologist and other relevant clinicians

1.5–2.0 l per day might be considered in patients with severe HF to relieve symptoms and congestion⁸⁰. When travelling to hot and dry destinations, an additional intake of 0.5–1.0 l per day of non-alcoholic drinks is recommended. Patients at risk of volume overload or on moderate-to-high doses of diuretics should be advised to regularly check their body weight. In case of body weight changes, patients can adjust doses of diuretics and the amount of fluid intake for a few days until body weight has normalized. Controlling sodium intake is

Box 5 | Travel-related activities and related cardiac events reported via remote monitoring

- Sports (such as swimming and diving)
 - Arrhythmias (atrial fibrillation, ventricular tachyarrhythmia or premature ventricular contractions)
 - Heart failure decompensation
 - Damage to the implanted cardiac lead (fracture or insulation failure)
 - Cardiac device compression with loss of function (during diving)
- Stay in high altitude
 - Arrhythmias (atrial fibrillation, ventricular tachyarrhythmia or premature ventricular contractions)
 - Heart failure decompensation
- Eating out (higher intake of sodium) and alcohol consumption
 - Heart failure decompensation
- Reduced adherence to medication
 - Arrhythmias
 - Heart failure decompensation
- Travel by aircraft
 - Arrhythmias (atrial fibrillation, ventricular tachyarrhythmia or premature ventricular contractions)
 - Heart failure decompensation
 - Electromagnetic interference with cardiac electronic device
- Travel by train or ship
 - Electromagnetic interference with cardiac electronic device

Box 6 | Considerations before and during travel for patients with an LVAD

Considerations before departure

- Approval should be sought from the responsible left ventricular assist devices (LVAD) centre, including an airline information letter (templates from LVAD manufacturer)
- Closest LVAD centres within the travel destination should be located as possible emergency contacts
- All LVAD-related equipment needs to be stored in carry-on luggage with handling advice and emergency contact information attached and batteries should be fully charged before departure
- The size and weight of the equipment should be checked to ensure that it can be carried on board the plane and the airport and airline need to be informed about the LVAD before arrival to the airport

Considerations during travel

- Flight attendants and other personnel need to be informed about the LVAD and the location of the emergency information card
- Patients need to maintain fluid intake to avoid low flow alarms from the LVAD pump
- For flights longer than 2 hours, support stockings should be considered

important for patients at risk of hyponatraemia and for the management of oedema, although evidence showing the effects of sodium intake on HF outcomes is scarce³. During travel, increased consumption of foods high in salt can adversely affect sodium and volume balance and thereby exacerbate HF symptoms by causing fluid retention. Patients with HF and cardiorenal syndrome and/or treated with RAAS inhibitors are at increased risk of hyperkalaemia⁸¹. In patients with advanced chronic kidney disease (estimated glomerular filtration rate <30 ml/min/1.73 m²), a daily sodium intake of <3 g is recommended⁸¹. These patients should also be aware that certain foods, such as fresh fruits, juices, vegetables and milk products, contain high amounts of potassium.

Drinking habits also change during vacation. Moderate-to-heavy alcohol consumption is associated with increased risk of supraventricular arrhythmias, especially atrial fibrillation, and high blood pressure^{82,83}. Therefore, increased intake of alcoholic beverages might aggravate HF symptoms and promote volume overload. Alcohol intake should be limited to two units per day for men with HF, one unit for women with HF, or no intake

if alcohol has caused or contributed to the individual's HF, as recommended by the ESC³.

Drug-induced photosensitivity

Numerous classes of drugs commonly used for the treatment of patients with HF have been associated with photo-induced, cutaneous drug eruptions, which are adverse effects that occur as a result of the exposure to a drug (and its presence in the skin) and ultraviolet or visible radiation⁸⁴. BOX 7 provides an overview of drugs that have been linked with drug-induced photosensitivity. Amiodarone can cause drug-induced photosensitivity in >50% of treated patients⁸⁴. The typical presentation of this adverse effect is a burning and tingling sensation in sun-exposed skin, with associated erythema. Amiodarone induces a distinctive blue–grey pigmentation on sun-exposed sites in 1–2% of patients, particularly after long-term sun exposure. Another prototypical drug class associated with photosensitivity is thiazide diuretics, which includes hydrochlorothiazide⁸⁵. Thiazide diuretics can trigger a variety of photosensitive eruptions, including an exaggerated sunburn reaction, dermatitis and a lichenoid eruption.

Various factors, such as time of day, season, geographical location, altitude and weather conditions, can affect the amount of ultraviolet radiation exposure⁸⁶. In general, patients with HF should be advised to seek shade when outside, in particular around midday, and to keep in mind that radiation can be stronger when reflected by water, sand or snow. Patients in areas with high sun exposure should wear clothing that protects as much of the body as possible as well as sunglasses and broad-brimmed hats. Broad-spectrum sunscreens with a sun protection factor of 30 or higher are recommended⁸⁶.

Considerations for drivers

Driving regulations for individuals with HF take into account the severity of HF (NYHA class plus left ventricular ejection fraction)⁵⁴. In the European Union, individuals with NYHA class I–III HF but not those with NYHA class IV HF are permitted to drive private vehicles. Patients with HF should ensure that they are permitted to drive in their travelling destination by accessing country-specific driving regulations online.

Fig. 2 | **Contributors to volume depletion during travel in patients with HF.** A vast array of factors contributes to volume depletion in patients with heart failure (HF) and require medication adjustment and increased fluid intake. MRA, mineralocorticoid receptor antagonists; SGLT2i, sodium–glucose cotransporter 2 inhibitor.

Box 7 | Medications linked to drug-induced photosensitivity⁸⁰

Angiotensin-converting enzyme inhibitors

Ramipril, enalapril and quinapril

Angiotensin receptor blockers

Candesartan, irbesartan, losartan, olmesartan, telmisartan and valsartan

Anti-arrhythmic drugs

Amiodarone and dronedarone

Anti-depressant drugs

Citalopram, clomipramine, escitalopram, fluoxetine, fluvoxamine, imipramine, paroxetine, sertraline, St. John's wort and venlafaxine

Antimicrobial drugs

Anti-fungals, anti-malarials, anti-tuberculous drugs, anti-retrovirals, β -lactams, fluoroquinolones, nalidixic acid, sulphonamides and tetracyclines

β -Blockers

Tilisolol

Calcium channel blockers

Amlodipine, diltiazem and nifedipine

Diuretics

Bumetanide, furosemide, indapamide, thiazides and triamterene

3-Hydroxy-3-methylglutaryl coenzyme A (HMG-CoA) reductase inhibitors

Atorvastatin, pravastatin and simvastatin

Non-steroidal anti-inflammatory drugs

Ampiroxicam, celecoxib, diclofenac, ibuprofen, indomethacin, ketoprofen, meclofenamide, nabumetone, naproxen, oxaprozin, piroxicam, sulindac and tiaprofenic acid

Psychotropic drugs

Anti-psychotic drugs (aripiprazole, chlorpromazine, clozapine, flupenthixol, haloperidol, olanzapine, risperidone and thioridazine) and anxiolytics (alprazolam and chlordiazepoxide)

Considerations for patients with ICDs

Electromagnetic interference. Many patients with HF are fitted with cardiac implantable electronic devices (CIEDs; namely ICDs), cardiac resynchronization

therapy devices or pacemakers. These devices might be subject to electromagnetic interference (EMI) if exposed to a strong electromagnetic field (TABLE 3). Exposure of the device to EMI can result in device failure (loss of anti-bradycardia pacing with the risk of asystole), switch to asynchronous mode (pacing at a preset rate independent of intrinsic rhythm with the risk of inducing arrhythmias, including ventricular fibrillation), inappropriate tracking (atrial oversensing leading to rapid, irregular ventricular pacing) and in the inappropriate detection of ventricular tachyarrhythmias by ICDs, potentially with inappropriate shock therapy. High-voltage lines above trains, for example, have a strong electromagnetic field but the patient is shielded when inside the train. In trams or underground trains, electric motors can be located under the seat, whereas in cars and motorbikes, the only relevant source of EMI is the ignition system. Patients with a cardiac implantable device should be careful not lean over an unshielded, running motor.

Air travel. Metal detectors at airport security checkpoints do not interfere with CIEDs^{87,88}. However, patients with ICDs should be advised to have their device card ready to show to airport personnel before walking through the security checkpoint. To minimize the risk of interference, patients should move through metal detector gates at normal walking speed and should not linger. Hand-held scanners should not affect CIED functionality⁸⁹ but patients should ask personnel to move the wand over the device quickly and only once.

Magnets are not allowed in carry-on luggage and thus cannot be used to remedy inappropriate device activity on airplanes. EMI inside airplanes is rare but has been reported, for example, in association with electronic chair handles. Finally, cosmic radiation is approximately 100-fold higher during air travel, which increases the risk of radiation-induced EMI (for example, power-on reset).

Conclusions

The list of considerations for patients with HF embarking on national or international travel is extensive. Patients should be aware of an increased risk of cardiovascular events during their travels, which can be reduced with meticulous pre-travel risk assessment, physical examination, therapy adjustment and education. Pre-travel risk assessment should involve research into the local climate, air pollution levels, the distance and time for travelling, potential jet lag and altitude. En route, patients with HF should avoid volume depletion caused by extended chair rest, low cabin humidity and cooled air, excess alcohol or coffee intake, drugs with diuretic effects, hypoxia or traveller's diarrhoea. Upon arrival at the destination, drug-induced photosensitivity and the health effects of local foods and beverages require consideration. Special recommendations are needed for patients after implantation of cardiac rhythm devices or LVADs as well as for patients who have undergone major cardiac surgery.

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Table 3 | Travel-related sources of electromagnetic interference that can affect CIED functionality

Electronic device/field	Risk of interference with CIED	Minimal distance to avoid interference
Electric motors (such as those in trams or boats)	Yes	30–60 cm
Ignition systems (such as those in cars)	Yes	30 cm
Global positioning system	No	NA
Barcode scanner	No	NA
Mobile phones	Yes	15 cm
Metal detectors (walk-through archways or hand-held wands)	No	Walk through at normal pace, do not stop or linger
Full-body imaging scanners (millimetre wave scanners and 3D-imaging scanners)	No	Do not linger
High-voltage lines (such as for trains)	Yes	Possible interaction from the platform, not from inside the train carriage
Magnet train (such as Transrapid)	No	NA

CIED, cardiac implantable electronic device; NA, not applicable.

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