SAFETY OF LONG DISTANCE AEROMEDICAL TRANSPORT OF THE CARDIAC PATIENT

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ABSTRACT

Although long distance aeromedical transport of cardiac patients occurs with increasing frequency, data regarding the incidence of complications are lacking and guidelines for air ambulance transport are nonexistent. The purpose of this thesis is to evaluate the safety of long distance aeromedical transport of cardiac patients, and to recommend a time frame for air ambulance transport of patients post myocardial infarction. An analysis of all long distance aeromedical transports performed by Montreal-based *Skyservice Lifeguard* from 98/1/1 to 98/10/1 is presented. 109 cardiac patients were transported; 83 by air ambulance and 26 commercially. All inflight complications were minor and resolved quickly. After analysis of the results, it is concluded that air ambulance transport of cardiac patients can safely be performed earlier than guidelines for commercial flights. Air ambulance transport appears safe post complicated myocardial infarction by day 7 or >72 hours chest pain free, and post uncomplicated myocardial infarction by day 3 or >48 hours chest pain free. Future guidelines for aeromedical transport of patients post myocardial infarction should distinguish between air ambulance and commercial flights.

RÉSUMÉ

Bien que le transport aéromédical longue distance de patients cardiaques se produit de plus en plus fréquemment, des données concernant l'incidence de complications nous manquent, et les directives sur le transport par ambulance aérienne sont inexistantes. Le but de cette thèse est d'évaluer la sécurité du transport aéromédical longue distance de patients cardiaques, et de recommander quand est-ce-qu'on peut transporter sans risque des patients par ambulance aérienne après un infarctus du myocarde. Une analyse de tous les transports aéromédicaux entrepris par *Skyservice Lifeguard* de Montréal du 01/01/98 au 01/10/98 est présentée. 109 patients cardiaques furent transportés; 83 par ambulance aérienne et 26 par avion commercial. Toutes les complications survenues durant les vols furent mineures et vite résolues. Suite à l'analyse des résultats, il est conclu que le transport de patients cardiaques par ambulance aérienne peut être effectué, en sécurité, plus tôt que les directives concernant les vols commerciaux. Le transport par ambulance aérienne semble approprié à la suite d'un infarctus du myocarde compliqué après 7 jours ou >72 heures sans douleur de poitrine, et à la suite d'un infarctus du myocarde non-compliqué après 3 jours ou >48 heures sans douleur de poitrine. Les directives futures pour le transport aéromédical de patients suite à un infarctus du myocarde devraient faire une distinction entre l'ambulance aérienne et les vols commerciaux.

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CONTRIBUTIONS OF MANUSCRIPT AUTHORS

1) Vidal Essebag's contributions included study design, data collection, statistical analysis, interpretation of results, writing the manuscript, and review of the manuscript.

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CHAPTER 1:

Introduction

Long distance aeromedical transport of cardiac patients has increased significantly in the past decade, due to a variety of medical, social and economic reasons. Despite the benefits of early aeromedical repatriation, there are potential risks involved in transporting cardiac patients. However, data documenting the frequency of such complications are lacking, and guidelines for air ambulance transport are nonexistent.

Over the past two years I have had the opportunity to participate in the aeromedical transport of many patients as a flight physician for the Montreal General Hospital affiliated *Skyservice Lifeguard* aeromedical transport service. On a few occasions, I have transported very ill cardiac patients from places where medical care was clearly inadequate. One particular case was that of a fifty-five year old man hospitalized at the Baffin Regional Hospital in Iqualuit – a town in the Northwest Territories with no nearby cardiologist or angiographic facility. This man was admitted to hospital for a myocardial infarction (heart attack) and treated with the thrombolytic (drug used to dissolve the thrombus or blood clot that causes a heart attack) agent tPA (tissue plasminogen activator). Within 24 hours, he suffered a second infarction and, after consulting with the Ottawa Heart Institute, his physician decided to administer a second dose of tPA and call for immediate aeromedical transfer to Ottawa. An aeromedical repatriation team including two pilots, two nurses and myself was immediately assembled. We flew by Lear Jet 35 Air Ambulance from Montreal to Iqualuit. By the time we arrived at the local hospital, the patient had had a third infarction and was suffering from severe pulmonary edema as a result of his failing heart. The best chance this patient had for survival was direct transfer to the Ottawa Heart Institute for coronary angiography and percutaneous coronary angioplasty or cardiac surgery. Fortunately, we successfully transferred the patient to Ottawa where the cardiologist and the angiography team awaited his arrival. This patient would likely have died if he had not been flown to Ottawa by air ambulance.

In an emergency situation such as the one described above, where urgently needed treatment is not locally available, it seems clear that aeromedical transport is justified. It is also apparent that aeromedical transport would not be justified for a similar patient admitted to a tertiary care hospital with facilities for coronary angiography and cardiac surgery. The risks of transporting such an unstable patient would contraindicate aeromedical transport regardless of the possible economic (e.g. a Canadian hospitalized in an American hospital) or social (e.g. patient and/or family preference to transfer to a city closer to home) benefits.

When a patient is to be air transported out of a hospital capable of providing adequate medical care, such transport must be considered **elective**. The elective aeromedical transport of a patient is very different from the emergent type of transfer described above. When evaluating the possibility of elective long distance aeromedical transport of a cardiac patient, one must carefully weigh the risks and benefits involved in early transport.

There are several ways a patient may fly home after admission for a cardiac event at a distant hospital. In order to fly by commercial airline unaccompanied, the patient is required to wait an appropriate period of convalescence (which may be over 6 weeks) after treatment and discharge from hospital. However, due to economic and social incentives for earlier repatriation, patients are being aeromedically transported with increasing frequency over the last 10 years. In some cases, airlines will accept a shorter convalescence period prior to commercial flight, if a trained medical escort (physician or registered nurse) accompanies the patient. In other cases, a private air ambulance jet (equipped with intensive care facilities, available medications, a physician and two nurses) is sent to repatriate the patient from one hospital directly to another hospital closer to home, for continued medical care.

Intuitively, it seems reasonable that a patient may be safely transported earlier by air ambulance. An earlier transfer may be preferred for economic and/or social reasons, but earlier transfer is likely associated with increased risk. The priority must remain patient safety. How soon can a cardiac patient, particularly after myocardial infarction, be safely aeromedically transported?

After reviewing the literature it became clear that data documenting the frequency of complications associated with elective long distance aeromedical transport of cardiac patients are sparse. There are no published studies that address the safety of elective air ambulance transport of patients post myocardial infarction. Furthermore, current guidelines concerning flight after myocardial infarction concern only patients flying commercially without medical escort; the guidelines do not address the issue of earlier transport with medical escort or aeromedical transportation by air ambulance.

The objectives of this manuscript-based thesis are therefore 1) to review the current literature on the aeromedical transport of cardiac patients, 2) to examine the safety of elective aeromedical transport of cardiac patients in general, 3) to study the safety of elective air ambulance transport of cardiac patients post myocardial infarction in particular, and 4) to suggest a timeframe for safe air ambulance transport post myocardial infarction.

The enclosed manuscript has recently been published in the Aerospace Medical Association's journal entitled *Aviation, Space, and Environmental Medicine.* (A copy of the published manuscript is included as Appendix 2, preceded by a letter (Appendix 1) from the Aerospace Medical Association granting permission to include it as part of this thesis.) The Aerospace Medical Association is the largest international organization for Aviation and Aerospace Medicine.

CHAPTER 2:

Background and Literature Review

I. The Impact and Potential Risks of Flight for a Cardiac Patient

The three main areas of concern regarding the aeromedical transport of cardiac patients are 1) the effects of hypoxia (low oxygen saturation in blood) at altitude, 2) the effects of anxiety about flying, and 3) the potential for complications related to movement of the patient.

1. Effects of Hypoxia at Altitude

Fixed wing aircraft generally fly at an altitude of 28000-43000 feet (1). Barometric pressure progressively decreases with altitude from 760 mmHg at sea level to 140 mmHg at 40000 feet. The partial pressure of oxygen (Po_2) is approximately 21% of the barometric pressure at any given altitude. Therefore, in accordance with Dalton's Law (which can be expressed as Po_2 = 0.21xBarometric Pressure), Po_2 decreases progressively and proportionally to the decrease in barometric pressure at increasing altitude. The Po_2 at 40000 (~29mmHg) feet is incompatible with human life. In order to make it possible for humans to fly at such altitudes, aircraft cabins are pressurized. Compressors force external air into the cabin to achieve a pressure differential of up to approximately 445mmHg between the cabin and the outside barometric pressure. With pressurization, the resulting cabin pressure at cruising altitudes is equivalent to barometric pressures at 5000-8000 feet altitude (2). Above 22500 feet altitude (where barometric pressure is 315mmHg, and pressurization can increase cabin pressure by 445mmHg to yield sea level pressure of 760mmHg), the cabin Po_2 is always decreased (1).

At a cabin pressure of 8000 feet, Po_2 decreases from 159mmHg at sea level to 116mmHg. In normal patients, this has been shown to decrease arterial partial pressure of oxygen (PaO_2) from 98 to 55 mmHg (1). In healthy individuals this results in only a small decrease in blood oxygen saturation to approximately 90%. However, if a patient already has a reduced PaO_2 on the ground (e.g. as a result of cardiac and/or pulmonary disease) the decrease in oxygen saturation (or desaturation) at altitude will be more significant and may lead to various complications

Bendrick et al studied inflight oxygen saturation decrements during the aeromedical evacuation of 24 patients with ischemic heart disease (prior MI or angina) whose resting ground saturations ranged from 92-100% (3). They found a mean saturation decrease of 5.5% at a mean cabin altitude of 6900 feet. Three patients were given supplemental oxygen for oxygen saturations that decreased below 90%. In another study, a group of patients with chronic obstructive lung disease whose baseline oxygen saturations averaged 93.2% were observed (4). At a simulated altitude of 10000 feet, their saturations dropped to 87.5%. Hypoxia was easily corrected with the administration of low flow oxygen.

The physiologic response to lowered PaO_2 is chemoreceptor-induced hyperventilation, mediated primarily by an increase in tidal volume (volume of air inspired per breath). Any residual systemic hypoxia is compensated for with increased cardiac output (amount of blood pumped through the heart per minute), mediated primarily through tachycardia (increase in heart rate) (2).

Malagon et al. examined changes in cardiac output during air ambulance missions. Six normal crew members and seven patients being transported internationally were studied (5). Cardiac output (estimated using cardiac doppler techniques) increased in patients, but remained unchanged in crew members. It is notable that none of the crew members became hypoxic during flight, which likely explains their lack of increase in cardiac output.

Hypoxia is a potentially serious problem for recently stabilized cardiac patients with coronary artery disease. A decrease in PaO_2 means a decreased supply of oxygen to heart muscle (myocardium) whose oxygen supply is already compromised by diseased (narrowed) arteries providing limited blood flow. While studies observing the frequency of angina in patients transported by air ambulance are lacking, there are data looking at the ischemic threshold of human subjects at high altitudes achieved by gradual ascent. One study performed treadmill testing on nine men with known coronary disease and exercise induced angina, initially at 5000 feet elevation and then one hour following ascent to 10000 feet altitude (6). Symptoms (angina) or electrocardiographic changes (ST segment depression) suggestive of cardiac ischemia (lack of oxygen) occurred at the same heart rate-blood pressure product (an index of the internal workload of the heart) at each altitude, but at a lower external workload (treadmill speed and incline) when at higher altitude. In other words, angina occurred with less provocation at higher altitudes, presumably due to decreased oxygen delivery to the myocardium.

Another reason why hypoxia is a concern in cardiac patients is that it is a known stimulus for atrial arrhythmias and has been shown to be associated with premature ventricular beats (2). In addition, the potential for increased sympathetic nervous system activity and catecholamine (e.g. adrenaline) levels inflight (as demonstrated in patients with acute MI transferred by helicopter (7)), is theoretically an additional risk factor predisposing to arrhythmia. Military pilots have been reported to experience transient (and mostly asymptomatic) atrial and ventricular arrhythmias during high G force flights (8). However, there are no data documenting the incidence of arrhythmia in patients undergoing long distance aeromedical transport.

2. Effects of Anxiety about Flight

A patient's anxiety level can have an impact on his or her cardiovascular status during transport. Cardiac ischemia can be provoked by tachycardia and elevated catecholamines resulting from extreme nervousness. A study in which anxiety levels during aeromedical transport were monitored noted that anxiety was greatest in anticipation of the flight (9). Patients with little or no experience flying were the most nervous. Their level of anxiety decreased steadily during the flight. Most patients were more anxious about their medical condition than the flight itself. It is reasonable to offer mild anxiolytics (medications that decrease anxiety) to patients that are anxious about flying, provided there are no contraindications.

3. Complications Related to Movement of the Patient

The transfer of hospitalized patients is associated with complications related to physical movement from a bed to a stretcher or examination table. Complications range in severity from minor (i.e. pulling out an intravenous line) to potentially life threatening (i.e. pulling out an endotracheal tube required for the ventilation of an intubated patient on a respirator). The risk of a complication relates to the amount of instrumentation of the patient, and to the complexity of the machinery. Critical care patients are therefore at greatest risk of a complication during transfer.

The frequency of complications during intra-hospital transport has been observed to be 5-6% (10). Meticulous packaging of a patient prior to any transfer is essential to minimize the risk of transport related complications.

II. Aeromedical Transport of Cardiac Patients

This section reviews the literature concerning aeromedical transport of cardiac patients. Distinctions are made between: 1) short distance (for which helicopters are generally employed) vs. long distance (for which fixed wing aircraft, either commercial airline or private air ambulance, are employed) transportation, 2) commercial airline vs. private air ambulance transportation, and 3) emergency vs. elective (i.e. transporting a patient from a location where adequate medical care is available to another location for economical and/or social reasons) transportation.

1. Short Distance (Emergency) Helicopter Transport

Aeromedical transport of cardiac patients is relatively new. The origins of aeromedical transportation date back to 1944 when the U.S. military first used helicopters for aeromedical evacuation of the injured in Burma (11). U.S. military helicopter evacuation dramatically expanded during the Vietnam War in the 1960s. The success of U.S. military helicopter evacuation in Vietnam established the foundation for, and acceptance of, helicopter transport in hospital systems (12).

Civilian helicopter emergency medical services have their roots in military aeromedical evacuation programs (13). In 1966, the United States Highway Safety Act allowed for the transfer of military helicopter technology for civilian use (11).

U.S. civilian air emergency medical services began in Denver in 1972. The number of civilian programs rapidly grew to a total of 280 by 1995 (13).

The technology of emergency helicopter aeromedical transport has also been applied to patients with acute cardiac illness. With the increasing availability of cardiac catheterization laboratories in tertiary care hospitals in the 1980s, the demand for emergency aeromedical transport of cardiac patients increased rapidly. Emergency helicopter aeromedical transport was a faster and more efficient way to transport patients from rural settings for reperfusion techniques like thrombolysis or angioplasty following acute myocardial infarction (MI).

The majority of data on aeromedical transportation of cardiac patients in general, come from such short distance emergency helicopter flights. Five major reports describe the aeromedical transfer of patients early in the course of acute MI (14,15,16,17,18).

A study by Kaplan et al. reports on 104 patients with suspected acute MI transferred by helicopter for emergency reperfusion within 36 hours of symptom onset (14). While there were no inflight deaths, inflight complications occurred in 13 patients (12%). The complications were serious hypotension in 9 patients and new arrhythmias requiring treatment in 4 patients. Physicians were required to exercise medical skills or judgement during 26% of the transports. Similarly, Bellinger et al. describe a study of 250 patients transported by helicopter within 12 hours of onset of symptoms of acute MI for emergent cardiac catheterization (15). Of the 240 patients who received thrombolytics, 72% had therapy instituted before or in-flight. Complications included hypotension in 25 patients (10%) and arrhythmias in 25 patients (10%). The inflight arrhythmias, which included third degree atrio-ventricular (AV) block (8 patients) and non sustained ventricular tachycardia (7 patients), did not result in any significant morbidity. No patients had ventricular fibrillation, asystole or respiratory arrest during helicopter transport. The authors concluded that inflight complications were infrequent and medically manageable en route to the cardiac catheterization centre.

A study by Topol et al. reported on 150 consecutive patients with evolving MI transported by helicopter to a tertiary care institution for acute intervention (16). No patients died or experienced hemodynamic instability or bleeding complications from thrombolytics during transfer. 55 patients received thrombolytic therapy initiated prior to transfer. Arrhythmic complications (ventricular tachycardia and third degree block), although increased in the population that received thrombolytics, were infrequent (8/150) and only transient. Immediate coronary angiography confirmed a higher incidence of infarct vessel patency in patients who received thrombolytic therapy.

A study by Fromm et al. compared 95 consecutive acute MI patients transported by helicopter within 12 hours of initiation of thrombolytic therapy to 119 nontransported acute MI patients similarly treated (17). Inflight complications included medically managed hypotension in 18 patients, but no episodes of cardiac arrest or cardioversion. There was no increase in bleeding complications compared to a nontransported control population. In Spangler's study of 192 acute MI patients transferred by helicopter, 110 received thrombolytic therapy prior to transfer and the remainder received thrombolytic therapy after transfer (18). The time from presentation to initiation of thrombolytic therapy was decreased in the patients treated prior to transfer. It is noted that patients with inferior MI treated with thrombolytics prior to flight were more likely to experience symptomatic bradycardia and hypotension requiring atropine compared to patients treated post flight, but there was no inflight mortality in either group.

In summary, the data on emergency helicopter transport of patients with acute MI suggest that such transport is safe, based on the absence of in-flight deaths or significant morbidity. The most frequent in-flight problems were non-fatal hypotension and arrhythmias, managed by onboard medical personnel equipped with intravenous fluids, and medications.

2. Long Distance Aeromedical Transport

Long distance aeromedical transport is performed using fixed wing (as opposed to rotary wing, i.e. helicopter) aircraft. Patients who are relatively stable may be transported aboard a commercial aircraft accompanied by a medical escort (physician or nurse) equipped with oxygen, fluids, medications, and other medical supplies. The transport of less stable patients requires a private jet air ambulance.

i. Long Distance (Elective) Commercial Transport

There is only one published study reporting on the safety of commercial air travel post MI. The study describes 196 commercially transported patients 3-53 days post MI, the majority (77%) of whom were flown between days 8-21 post MI (19). There were only 9 incidents requiring physician intervention, 6 of which occurred in the patients transported less than 14 days post MI. Four of these six incidents can be classified as cardiac, and each resolved after physician intervention. The authors conclude that international aeromedical transport of patients by commercial airline may be safely accomplished 2-3 weeks post acute MI when accompanied by a physician.

ii. Long Distance (Emergency) Air Ambulance Transport

Fixed wing air ambulances have been used for emergency aeromedical transport of cardiac patients requiring transport to tertiary centres from locations too distant for helicopter transport (i.e. greater than 250 km) (11). Operational units dedicated to emergent long distance aeromedical evacuation on fixed-wing aircraft were first organized by the U.S. military in 1943 (20). Due to the dramatic evolution in medical care since World War II, more unstable patients (including cardiac patients post MI) are being aeromedically transferred for more advanced diagnosis and therapy in recent years (20).

The long distance emergent transport of cardiac patients by fixed wing air ambulance is documented in three studies.

One study describes 11 patients in cardiogenic shock (on intravenous inotropic support, eight requiring intra-aortic balloon pumps), transported a median of 1160 miles: 6 patients by air ambulance, and 5 by ground ambulance (21). All patients survived the transport without any medical complications of travel. A second study detailed the aeromedical evacuation of 7 patients after acute myocardial infarction by the United States Air Force (22). All patients were transported from remote areas to larger medical facilities capable of providing adequate medical care. The patients were transported within 7 days of symptom onset, after thrombolysis and at least 24 hours of hemodynamic stability. Transportation time ranged from 4.4 to 12.2 hours, and there were no inflight complications.

A third study reports the transoceanic air evacuation of 59 patients with unstable angina requiring care not locally available (23). Inflight information available for 31 patients revealed only minor inflight complications in 6 patients. Review of inpatient records at receiving hospitals confirmed significant coronary artery disease in the majority of patients, and the absence during admission of complications attributable to aeromedical transfer.

iii. Long Distance (Elective) Air Ambulance Flights

The manuscript presented in this thesis is the first published study (to my knowledge) on the elective long distance aeromedical transportation of cardiac patients post MI by air ambulance.

III. Current Guidelines Regarding Long Distance Flight and Cardiac Patients

The current guidelines regarding long distance flight and cardiac patients are limited to commercial airline travel. The American College of Cardiology (ACC) and American Heart Association (AHA) recommend that following uncomplicated MI, stable patients (without fear of flying) may travel by air within the first 2 weeks, provided they are accompanied by companions, carry sublingual nitroglycerin, and request airport transportation to avoid rushing (24). Patients who are unstable, symptomatic, or who experienced a complicated MI (requiring CPR, experiencing hypotension, serious arrhythmias, high-degree block, or congestive heart failure (CHF)), are recommended to wait a period of at least two weeks following stabilization before commercial air travel. The guidelines of the Aerospace Medical Association (AsMA) state that unescorted commercial airline flight is contraindicated within 3 weeks of uncomplicated MI, within 6 weeks of complicated MI, within 2 weeks of coronary artery bypass graft (CABG), or within 2 weeks of cerebrovascular accident (CVA) (25). Other cardiovascular contraindications to commercial airline flight include unstable angina, severe decompensated CHF, uncontrolled hypertension, uncontrolled ventricular or supraventricular tachycardia, eisenmenger's syndrome, and severe symptomatic valvular heart disease. The American Medical Association (AMA) guidelines indicate that travel by commercial aircraft is contraindicated within 4 weeks after MI, within 2 weeks after CVA, and for anyone with severe hypertension or decompensated cardiovascular disease (1). The above guidelines are summarized in Tables 1 and 2 below.

Table 1. Guidelines proposing time frame within which air travel is contraindicated after a myocardial infarction (MI).

Association	MI uncomplicated	MI complicated
ACC/AHA	2 weeks	2 weeks after stable
AsMA	3 weeks	6 weeks
AMA	4 weeks	4 weeks

ACC, American College of Cardiology; AsMA, Aerospace Medical Association; AMA, American Medical Association.

Table 2. Guidelines for other cardiovascular contraindications to air travel.

Association	Other Contraindications
ACC/AHA	N/A
AsMA	CABG (2 wks), CVA (2 wks) Uncontrolled Arrhythmia, HTN Severe CHF, VHD Unstable Angina, Eisenmenger's Syndrome
AMA	Severe HTN, decompensated cardiovascular disease

ACC, American College of Cardiology; AsMA, Aerospace Medical Association; AMA, American Medical Association; CABG, coronary artery bypass graft surgery; CVA, cerebrovascular accident; HTN, hypertension; CHF, congestive heart failure; VHD, valvular heart disease.

With the advent of fixed wing air ambulances equipped with intensive care facilities, cardiac patients are being transported earlier than these recommendations for commercial air travel. Although it seems reasonable that patients could be safely transported sooner under these circumstances, there are no established peer reviewed guidelines at the present time regarding transport of cardiac patients by fixed wing air ambulance.

CHAPTER 3:

Methodology

As previously mentioned, the objectives of this thesis are 1) to examine the safety of elective aeromedical transport of cardiac patients in general, 2) to study the safety of elective air ambulance transport of cardiac patients post myocardial infarction in particular, and 3) to suggest a timeframe for safe air ambulance transport post myocardial infarction.

These objectives are addressed by studying long distance aeromedical transports performed by the Montreal based *Skyservice Lifeguard* medical transport service during the period 98/1/1 to 98/10/1. The files of all patients transported during the study period were carefully reviewed searching for patients with cardiac diagnoses including myocardial infarction, unstable angina, arrhythmia, and congestive heart failure. A total of 109 patients with cardiac diagnoses were identified, and all were included in the study. Preflight evaluations and inflight medical assessments were available for all patients on standardized *Skyservice Lifeguard* forms.

Using *Filemaker Pro* software, a database form (a copy of which is attached as Appendix 3) was prepared in order to record all pertinent data abstracted from these preflight evaluations and inflight assessments. In particular, data were collected regarding age and sex; in-hospital diagnoses and procedures, including post procedure intervals; type of flight (air ambulance vs. commercial); status at the time of transport including days since admission, chest pain free interval, ground oxygen use, intravenous medications, and mechanical ventilation; duration of transportation; and details of inflight complications including interventions and outcomes.

Skyservice Lifeguard is a Montreal-based company that provides aeromedical repatriation services nationally and internationally, to and from countries spanning most of the globe. Preflight evaluations are initially performed by telephone from Montreal prior to making transport arrangements. The decision to transport the patient depends upon a subsequent evaluation (including history, physical examination, and review of chart and investigation results) performed on site by the flight physician and/or nurse prior to transportation. Although cases are assessed individually, *Skyservice Lifeguard* has general guidelines for elective aeromedical transport of cardiac patients. These guidelines, summarized in the following manuscript, are included in their entirety as Appendix 4. (Two *Skyservice Lifeguard* brochures, attached as Appendix 5, include photographs and information about the medical personnel, medical equipment, and aircraft available for air ambulance transport.)

A bivariate statistical analysis in presented in the following manuscript using chi-square tests on counts. Differences between patients transported by AA and C with respect to in-hospital diagnoses and procedures and status at time of transportation were assessed. Patients with MI were examined separately and differences in procedures and clinical status between uncomplicated MI (Killip I) and complicated MI (Killip II-IV) patients were also analyzed. To examine the possible modifying effect of the timing of transport on the risk of complications in the Killip I and Killip II-IV patients, a stratified analysis was carried out. A chi-square test assessing the differences in complication risk in Killip I patients vs. Killip II-IV patients was performed for each level of days since admission and chest pain free interval.

Additional analysis using multivariable logistic regression, in order to simultaneously adjust for differences in patients' medical conditions and potential confounders, is presented in chapter 5. First, patients transported by C are compared to those transported by AA. Then the subgroup of 51 patients transported by AA post MI were analyzed separately in order to focus specifically on issues regarding AA transport post MI.

CHAPTER 4:

Manuscript

The following 22 pages contain the final version of the manuscript published in *Aviation, Space, and Environmental Medicine*, the journal of the Aerospace Medical Association. A letter from the Aerospace Medical Association granting permission to include the article as part of this thesis is attached as Appendix 1. A copy of the published article is included as Appendix 2.

The manuscript contains the results of the primary analysis of 109 cardiac patients aeromedically transported by *Skyservice Lifeguard* from 98/1/1 to 98/10/1. Of these 109 patients, 51 were transported by air ambulance after a myocardial infarction (MI); these patients were analyzed separately comparing the 25 with complicated MI to the 26 with uncomplicated MI. In this manuscript, the statistical analysis is carried out using chi-square tests on counts. Additional analysis using logistic regression is presented in chapter 5.

SAFETY OF LONG DISTANCE AEROMEDICAL TRANSPORT OF THE CARDIAC PATIENT: A RETROSPECTIVE STUDY

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Running Head: Cardiac Patient Air Transport

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ABSTRACT

Background. The purpose of this study is to provide data regarding the safety of long distance air transport of cardiac patients, establish a time frame for safe transport, and assess current guidelines for post myocardial infarct (MI) transport. **Methods.** Retrospective analysis of all long distance aeromedical transports performed by Montreal-based *Skyservice Lifeguard* from 98/1/1 to 98/10/1. **Results.** 109 cardiac patients were transported; 83 by air ambulance (AA), and 26 commercially (C). Diagnoses included MI (63%), unstable angina (31%), congestive heart failure (21%), and arrhythmia (17%). Patients were transported a mean of 7 days (AA) vs. 13.7 days (C) after presentation. Inflight complications, occurring in 10% of AA and 4% of C flights, were minor (chest pain, desaturation, and hypotension), and resolved quickly. In 51 post MI AA patients, complication rate for transport >7 days after admission was 0% (vs. 14% <7 days), and >72 hours after last chest pain was 6% (vs. 18% <72 hours). Comparing uncomplicated (N=25) vs. complicated (N=26) MI reveals fewer complications for transport 0-3 days (13% vs. 50%) and 4-7 days (9% vs. 14%) after admission, and 48-72 hours after last chest pain (0% vs. 100%). **Conclusions.** AA transport of cardiac patients can safely be performed earlier than guidelines for C flights. AA transport appears safe post complicated MI by day 7 or >72 hours chest pain free, and post uncomplicated MI by day 3 or >48 hours chest pain free. Future guidelines for aeromedical transport post MI should distinguish between C and AA.

Keywords: medevac, air ambulance, air evacuation, aeromedical transport, cardiac transport, patient transport, myocardial infarction, unstable angina

INTRODUCTION

Aeromedical repatriation of cardiac patients hospitalized internationally has increased significantly in the past decade, for a combination of medical, social and economic reasons. This has been facilitated by the advent of fixed wing aircraft equipped to function as intensive care units for long distance aeromedical transportation.

Despite the benefits of early repatriation, there are potential risks involved in the aeromedical transport of cardiac patients. These include the physiological effects of hypoxia and neuroendocrine activation that may result in ischemia or arrhythmia (2), the mental effects of transport related anxiety (8), and the possibility of physical injury related to movement of patients. However, data documenting the frequency of such complications during long distance high altitude flight are lacking.

The majority of data on aeromedical transportation of cardiac patients come from short distance helicopter medevac flights to transport patients from rural settings for reperfusion techniques like thrombolysis or angioplasty following acute myocardial infarction (MI). Five major reports describe the aeromedical transfer of patients early in the course of acute MI (4,9,11,13,14). The data suggest that such transport is safe, based on the absence of in-flight deaths or significant morbidity. The most frequent in-flight problems were non-fatal hypotension and arrhythmias, managed by onboard medical personnel equipped with intravenous fluids, antiarrhythmics, thrombolytics, and nitroglycerin.

Fixed wing aircraft have generally been reserved for the long distance transport of stabilized cardiac patients, days or weeks after their acute presentation. Such transport can be performed by commercial airline (C) or specialized fixed wing air ambulance (AA).

The current guidelines regarding long distance flight and cardiac patients concern commercial airline travel. The American College of Cardiology (ACC) and American Heart Association (AHA) recommend that following uncomplicated MI, stable patients (without fear of flying) may travel by air within the first 2 weeks, provided they are accompanied by companions, carry sublingual nitroglycerin, and request airport transportation to avoid rushing (12). Patients who are unstable, symptomatic, or who experienced a complicated MI (requiring CPR, experiencing hypotension, serious arrhythmias, high-degree block, or congestive heart failure (CHF)), are recommended to wait a period of at least two weeks following stabilization before commercial air travel. The guidelines of the Aerospace Medical Association (AsMA) state that unescorted commercial airline flight is contraindicated within 3 weeks of uncomplicated MI, within 6 weeks of complicated MI, within 2 weeks of coronary artery bypass graft (CABG), or within 2 weeks of cerebrovascular accident (CVA) (1). Other cardiovascular contraindications to commercial airline flight include unstable angina, severe decompensated CHF, uncontrolled hypertension, uncontrolled ventricular or supraventricular tachycardia, eisenmenger's syndrome, and severe symptomatic valvular heart disease. The American Medical Association (AMA) guidelines indicate that travel by commercial aircraft is contraindicated within 4 weeks after MI, within 2 weeks after CVA, and for anyone with severe hypertension or decompensated cardiovascular disease (3).

With the advent of fixed wing air ambulances equipped with intensive care facilities, cardiac patients are being transported earlier than these recommendations for commercial air travel. Although it seems reasonable that patients could be safely transported more acutely under these circumstances, there are no established peer reviewed guidelines at the present time regarding transport of cardiac patients by fixed wing air ambulance.

METHODS

A retrospective analysis was performed of all long distance aeromedical transports performed by the Montreal based *Skyservice Lifeguard* medical transport service during the period 98/1/1 to 98/10/1. All files were carefully reviewed searching for patients with cardiac diagnoses including myocardial infarction, unstable angina, arrhythmia, and congestive heart failure. A total of 109 patients with cardiac diagnoses were identified, and all were included in the study. Preflight evaluations and inflight medical assessments were available for all patients on standardized *Skyservice Lifeguard* forms.

Using *Filemaker Pro* software, a database form was prepared in order to record all pertinent data collated from these preflight evaluations and inflight assessments. In particular, data were collected regarding age and sex; in hospital diagnoses and procedures, including post procedure intervals; type of flight (air ambulance vs. commercial); status at the time of transport including days since admission, chest pain free interval, ground oxygen use, intravenous medications, and mechanical ventilation; duration of transportation; and details of inflight complications including interventions and outcomes.

Skyservice Lifeguard is a Montreal-based company that provides aeromedical repatriation services nationally and internationally, to and from countries spanning most of the globe. Preflight evaluations are initially performed by telephone from Montreal prior to making transport arrangements. The decision to transport the patient depends upon a subsequent evaluation (including history, physical examination, and review of chart and investigation results) performed on site by the flight physician and/or nurse prior to transportation. Although cases are assessed individually, *Skyservice Lifeguard* has general guidelines for elective aeromedical transport of cardiac patients. Patients with unstable angina should be pain free for at least 24 hours. Patients with MI should be pain free for at least 48 hours. Patients should be free of hemodynamically unstable arrhythmias for at least 24 hours. Post procedure intervals for pacemaker, angiography, percutaneous transluminal angioplasty (PTCA), and CABG, should be at least 12, 12, 24 and 72 hours respectively.

Data are reported as percentages. Differences between patients transported by AA and C with respect to in-hospital diagnoses and procedures and status at time of transportation were assessed using chi-square tests on counts (Tables I and II). Patients with MI were examined separately and differences in procedures and clinical status between uncomplicated MI (Killip I) and complicated MI (Killip II-IV) patients were also analyzed using chi-square tests (Table IV). To examine the possible modifying effect of the timing of transport on the risk of complications in the Killip I and Killip II-IV patients, a stratified analysis was carried out. A chi-square test assessing the differences in complication risk in Killip I patients vs. Killip II-IV patients was performed for each level of days since admission and chest pain free interval (Table V). All P values were rounded to the nearest thousandth. P values less than 0.05 were considered statistically significant.

RESULTS

During the study period, 109 admitted patients with cardiac diagnoses underwent long distance aeromedical transportation; 83 by Lear Jet 35 air ambulance (AA), and 26 commercially (C). The study population consisted of 81 males and 28 females. The mean age of males was 65.7 years (range 33-89), and the mean age of females was 71.3 years (range 47-87).

In these 109 patients with at least one cardiac diagnosis, the frequency of myocardial infarction, unstable angina, CHF, and arrhythmia, was 63%, 31%, 21%, and 17% respectively (TABLE I). Although the frequency of MI was similar in the AA and C groups (61% Vs. 69%), the proportion of MIs that were uncomplicated (Killip I) was greater in the C (14 of 18 MIs) than in the AA (25 of 51 MIs) group ($P=0.034$). Revascularization procedures (PTCA or CABG), performed prior to transportation in 17% of the total group, were more common in the C (38%) than the AA (10%) group ($P<0.001$).

Patients in the AA group were transported earlier with 73% of AA group vs. 19% of C group transported within 7 days of admission ($P<0.001$) (TABLE II). AA patients were transported at a mean of 7 days post admission vs. 13.7 days for C patients. Significantly more patients were transported greater than 2 weeks post admission by C ($P<0.001$). Transportation was undertaken within 72 hours of last chest pain in 37% of AA vs. 8% of C patients ($p=0.004$). At the time of transport of AA patients, treatment at local hospital included oxygen (in 42% of patients), intubation and mechanical ventilation (2%), heparin (39%), nitroglycerin (20%), vasopressors (7%), and antiarrhythmics (6%). None of the C patients were on oxygen (on ground) or intravenous medications. The mean duration of transportation was 6.4 hours for AA patients and 11 hours for C patients.

There were no major inflight complications (i.e. death, myocardial infarction, or failure to complete transport). Minor inflight complications occurred in 9/109 (8%) of patients; 8/83 (10%) AA patients, and 1/26 (4%) of C patients. The minor complications consisted of chest pain in 6 patients, desaturation (saturation <91% with or without symptoms) in 2 patients, and hypotension (systolic BP decrease by >15mmHg requiring introduction or increase of vasopressor) in 1 patient. All minor inflight complications resolved after treatment with onboard medications, and did not result in any significant morbidity (TABLE III).

To address the specific question of the safety of long distance air ambulance transport post MI, we separately analyzed the group of 51 patients transported by AA post MI: 26 patients with complicated MI (Killip II-IV), and 25 patients with uncomplicated MI (Killip I) (TABLE IV). Of the 51 patients, 30% had Cath, PTCA or CABG prior to transport. Transportation occurred within 14 days for 87%, within 7 days for 69%, and within 3 days for 20%. Chest pain free interval was less than 72 hours for 33%, less than 48 hours for 12%, and less than 24 hours for 6%. Patients with uncomplicated MI were transported sooner than those with complicated MI: average of 6.3 vs. 9.6 days post admission. Also, transportation within 72 hours of last chest pain occurred in 52% of uncomplicated MIs vs. 15% of complicated MIs (P=0.006).

While there were no major complications, minor complications occurred in 5 of 51 post MI patients, the details of which are described in TABLE III (the first 5 patients). The frequency of minor complications in subgroups of patients divided according to time of transportation (days since admission) and chest pain free interval is detailed in TABLE V. Complications occurred in 14% (5/35) of patients transported 0-7 days post MI vs. 0% (0/16) of patients transported >7 days post MI. Complications occurred in 18% (3/17) of patients transported within 72 hours of last chest pain vs. 6% (2/34) of patients transported >72 hours post last chest pain.

Comparison of complicated and uncomplicated MI groups suggests a difference in incidence of minor complications (TABLE V). For patients transported at 0-3 days post admission, incidence of complications in uncomplicated MI patients was 13% vs. 50% for complicated MI. Patients transported at 4-7 days had incidences of 9% vs. 14% for uncomplicated and complicated MI groups respectively. In patients transported 48-72 hours post last chest pain, a complication occurred in the complicated MI group but not in the uncomplicated MI group.

DISCUSSION

Modern day air ambulances have true intensive care capabilities, allowing transport of critically ill patients. Compact technology exists to analyze blood gases and electrolytes during flight, compact mechanical ventilators, and all forms of intravenous medications are at the disposal of the flight physician. There are often medical, economic and social pressures to return a patient to their country or medical system, but these must be weighed against the possible risks of long distance aeromedical transport.

There are few published studies of long distance aeromedical transport of cardiac patients. In a recent study of 196 commercially transported patients 3-53 days post MI (7), the majority (77%) of patients were flown between days 8-21 post MI. There were only 9 incidents requiring physician intervention, 6 of which occurred in the patients transported less than 14 days post MI. Four of these six incidents can be classified as cardiac, and each resolved after physician intervention.

The long distance transport of active cardiac patients by fixed wing air ambulance is documented in three studies. One study describes 11 patients in cardiogenic shock (on intravenous inotropic support, eight requiring intra-aortic balloon pumps), transported a median of 1160 miles: 6 patients by air ambulance, and 5 by ground ambulance (10). All patients survived the transport without any medical complications of travel. A second study detailed the airlift of 7 military personnel after acute myocardial infarction (6). The patients were transported within 7 days of symptom onset, after thrombolysis and at least 24 hours of hemodynamic stability. Transportation time ranged from 4.4 to 12.2 hours, and there were no complications. A third study reports the transoceanic air evacuation of 59 patients with unstable angina requiring care not locally available (5). Inflight information available for 31 patients revealed only minor inflight complications in 6 patients. Review of inpatient records at receiving hospitals confirmed significant coronary artery disease in the majority of patients, and the absence during admission of complications attributable to aerovac transfer.

The current guidelines of the ACC/AHA, AsMA, and AMA, as mentioned in the introduction, concern commercial air travel. Given the paucity of publications about long distance aeromedical transport of cardiac patients, and the absence of specific guidelines for fixed wing AA transport, this study was undertaken to provide data regarding the safety of AA transport, and to aid in establishing guidelines for AA transport.

In this study of 109 cardiac patients (83 AA and 26 C), patients were transported by AA sooner (7 vs. 13.7 days post admission on average) and with fewer invasive procedures done prior to transport (27% vs. 50%), than those transported by C. This was accomplished safely, without any major complications, and with only a slightly greater incidence of minor complications (10% vs. 4%), all of which were easily resolved with onboard management.

In the subanalysis of 51 post MI patients (26 complicated and 25 uncomplicated MI) transported by AA, minor complications occurred in 10% of patients, all of whom were transported within 7 days of admission. The incidence of minor complications in patients transported with chest pain free interval of <48 hours, 48-72 hours, and >72 hours, was 33%, 9%, and 6% respectively. Patients with uncomplicated MI transported by day 3 post admission had an incidence of complications of 13%

compared to 50% for complicated MI. Patients transported on days 4-7 had an incidence of complications of 9% vs. 14% for uncomplicated and complicated MI groups respectively. In considering chest pain free interval, we can only focus on patients transported chest pain free >48 hours because *Skyservice Lifeguard*'s guidelines (see Methods) generally require 48 hours chest pain free post MI for elective aeromedical transportation. The 6 patients transported within 48 hours are likely to have been transferred on a more urgent basis, and are therefore not representative of patients undergoing elective transport. In patients transported 48-72 hours post last chest pain, one complication occurred in the complicated MI group while none occurred in the uncomplicated MI group. The complication rate in post MI patients transported >72 chest pain free was 6% with no significant difference between complicated and uncomplicated MI groups.

This study is limited by the fact that it is a case series of a heterogeneous patient population selected by retrospective chart analysis. Although the charts were well documented, it is impossible to ascertain the accuracy of all reported data. The sample size and small number of events limit the statistical power of the study, especially in subgroup analysis. There is also no follow up to rule out the possibility of delayed effects of aeromedical transport, although a previous study (5) suggests the absence of delayed complications attributable to long distance aeromedical transport of patients with acute coronary syndromes.

The data presented in this study suggest that elective AA transport of patients post complicated MI may be safely accomplished by day 7 post admission or after 72 hours chest pain free, with a low incidence of easily reversible minor complications.

For patients post uncomplicated MI, the study suggests the safety of transportation by day 3 post admission or after 48 hours chest pain free, again with a low incidence of easily reversible minor complications. Transport may be considered sooner when adequate medical care, including urgently needed invasive procedures, is unavailable locally.

Further studies are needed to properly examine the relevant risk factors involved in long distance repatriation, and to identify the patient populations suitable to fly. Databases of prior flights should be archived and inflight complications scrutinized to identify potentially reversible precipitants. Well-designed prospective studies are needed to better define criteria for safely transporting cardiac patients by air. Future guidelines for aeromedical transport of cardiac patients must distinguish between C and AA transport.

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TABLE I. IN HOSPITAL DIAGNOSES AND PROCEDURES

Diagnoses & Procedures	Combined (N=109)	Air Ambulance (N=83)	Commercial (N=26)	P Value
Diagnoses				
Unstable Angina	31%	29%	38%	0.359
MI (total)	63%	61%	69%	0.472
Killip I	36%	30%	54%	0.034*†
Killip II	5%	5%	4%	
Killip III	15%	17%	8%	
Killip IV	8%	10%	4%	
CHF	21%	24%	12%	0.171
Arrhythmia	17%	20%	8%	0.134
Procedures				
Revascularization (total)	17%	10%	38%	<0.001*
CABG	6%	2%	19%	0.002*
PTCA	10%	7%	19%	0.076
Cath‡	11%	13%	4%	0.181
Pacemaker	4%	4%	4%	0.956
Intubation§	9%	11%	4%	0.181
Thrombolysis	12%	13%	8%	0.445

* Statistically significant difference between Air Ambulance and Commercial (P<0.05)

† Comparison between Killip I MI and Killip II-IV MI

‡ Patients who had a Cath but no PTCA or CABG prior to transport

§ Excluding intubations required for surgery

TABLE II. STATUS AT TIME OF TRANSPORTATION

Status at time of transportation	Combined (N=109)	Air Ambulance (N=83)	Commercial (N=26)	P Value
Days since admission				
0-3	21%	28%	0%	0.003*
4-7	39%	46%	19%	
8-14	23%	17%	42%	
>14	17%	10%	38%	<0.001*
≤7	61%	73%	19%	<0.001*
Chest pain free interval				
<24 hours	4%	5%	0%	0.254
24-48 hours	8%	11%	0%	
48-72 hours	18%	22%	8%	
≤72 hours	30%	37%	8%	0.004*
No chest pain	7%	8%	4%	0.434
IV medications				
Heparin	29%	39%	0%	<0.001*
Nitroglycerin	16%	20%	0%	0.012*
Vasopressors†	6%	7%	0%	0.158
Antiarrhythmics‡	5%	6%	0%	0.200
Intubated	2%	2%	0%	0.424
O2 use on ground	32%	42%	0%	<0.001*

* Statistically significant difference between Air Ambulance and Commercial (P<0.05)

† 4 patients on dopamine alone, and 2 patients on both dopamine and dobutamine

‡ 4 patients on lidocaine alone, and 1 patient on both procainamide and amiodarone

TABLE III. COMPLICATIONS DURING TRANSPORT

Type of transport	Age & Sex	Hosp diagnoses & procedures	Status at time of transportation	Duration of Transport	Complications	Interventions and outcome
AA	44M	UA, MI (Killip II)	4d post adm, CP free <24h, 2L O2, IV Heparin	5 hours	Chest pain inflight	Resolved after NTG spray x2, ↑ O2, lasix
AA	54M	MI, (Killip I) Thrombolysis	5d post adm, CP free >72h, 2L O2, IV Hep	3 hours	Chest pain x1 inflight, x1 on ground	Each resolved with NTG spray x1
AA	68F	MI, (Killip III) Arrhythmia (VT)	2d post adm, CP free >48 but <72h, no O2, IV Hep	6 hours	Chest pain inflight	Resolved with NTG spray x1 and morphine
AA	47F	MI, (Killip I) Thrombolysis	2d post adm, CP free <24h, 4L O2, IV Hep + NTG	3 hours	Chest pain inflight	Resolved after ↑ NTG
AA	82M	MI, (Killip III) CHF	5d post adm, CP free >72h, no O2	7 hours	Desaturation inflight	Resolved with ↑ O2
AA	67M	UA	4d post adm, CP free >48h but <72h, 2L O2, IV Hep + NTG	5 hours	Chest pain inflight	Resolved with 2mg IV morphine
AA	75M	Arrhythmia (Afib)	5d post adm, no CP, no O2	5 hours	Desaturation inflight	Resolved with ↑ O2 and lasix
AA	71M	CHF	46d post adm, CP free >72h, 8L O2, IV dopamine	9 hours	Hypotension inflight	Resolved after ↑ dopamine
C	73M	UA	9d post adm, CP free >72h, no O2, refused cath	10 hours	Chest pain inflight	Resolved with O2 and NTG spray x3

AA, air ambulance; C, commercial airline; M, male; F, female; UA, unstable angina; MI, myocardial infarction; VT, ventricular tachycardia; CHF, congestive heart failure; Afib, atrial fibrillation; d, days; CP, chest pain; O2, oxygen; IV, intravenous; Hep, heparin; NTG, nitroglycerin.

TABLE IV. POST MI PATIENTS TRANSPORTED BY AIR AMBULANCE

Status at time of transportation	All MI (N=51)	Complicated MI (N=26)	Uncomplicated MI (N=25)	P Value
Procedures Done				
CABG	4%	4%	4%	0.977
PTCA	12%	4%	20%	0.073
Cath†	14%	15%	12%	0.725
Pacemaker	4%	8%	0%	0.157
Intubation	6%	12%	0%	0.080
Thrombolysis	22%	12%	32%	0.076
Days since admission				
0-3	20%	8%	32%	0.029*
4-7	49%	54%	44%	
>7	31%	38%	24%	0.266
Chest pain free interval				
<24 hours	6%	4%	8%	0.529
24-48 hours	6%	8%	4%	
48-72 hours	22%	4%	40%	
$\leq$72 hours	33%	15%	52%	0.006*
IV medications				
Nitroglycerin	25%	15%	36%	0.091
Heparin	37%	31%	44%	0.329
Vasopressors‡	8%	15%	0%	0.041*
Antiarrhythmics§	6%	12%	0%	0.080
O2 use on ground				
None	65%	54%	76%	0.099
>4 L	4%	8%	0%	0.157

* Statistically significant difference between complicated & uncomplicated MI ($P<0.05$)

† Patients who had a Cath but no PTCA or CABG prior to transport

‡ 3 patients on dopamine alone, and 1 patient on both dopamine and dobutamine

§ 2 patients on lidocaine alone, and 1 patient both amiodarone and procainamide

TABLE V. COMPLICATIONS IN POST MI PATIENTS TRANSPORTED BY AIR AMBULANCE

Subgroups	All MI (N=51)	Complicated MI (N=26)	Uncomplicated MI(N=25)	P Value
Days since admission				
0-3	2/10 (20%)	1/2 (50%)	1/8 (13%)	0.236
4-7	3/25 (12%)	2/14 (14%)	1/11 (9%)	0.692
>7	0/16 (0%)	0/10 (0%)	0/6 (0%)	
Chest pain free interval				
<48 hours	2/6 (33%)	1/3 (33%)	1/3 (33%)	1
48-72 hours	1/11 (9%)	1/1 (100%)	0/10 (0%)	0.001*
>72 hours	2/34 (6%)	1/22 (5%)	1/12 (8%)	0.654
Total	5/51 (10%)	3/26 (12%)	2/25 (8%)	0.671

* Statistically significant difference between complicated & uncomplicated MI (P<0.05)

CHAPTER 5:

In addition to the analysis presented in the manuscript, the data were also analyzed using multivariable logistic regression (with SAS software) in order to simultaneously adjust for differences in patients' medical conditions and potential confounders. First, a comparison was made between patients transported by air ambulance (AA) vs. those transported by commercial airline (C). Then the subgroup of 51 patients transported by AA post myocardial infarction (MI) were analyzed separately in order to focus specifically on issues regarding AA transport post MI.

I. Air Ambulance (AA) vs. Commercial (C) Transports:

Using all 109 patients, a logistic regression analysis was performed in order to evaluate differences between patients transported by AA vs. CC. Here, flight type (AA vs. C) was the dependent variable. Stepwise model selection (with significance level of 0.15 to enter and 0.25 to stay in the model) was used with 6 categorical (binary) independent variables (i.e. sex, revascularization procedure prior to transport (yes/no), myocardial infarction (yes/no), unstable angina (yes/no), arrhythmia (yes/no), and congestive heart failure (yes/no)) and 2 continuous independent variables (i.e. age in years at the time of transport and days since admission).

Following the stepwise procedure only days since admission and the presence/absence of congestive heart failure were retained in the model. Table I gives the point estimates and 95% confidence intervals for the odds ratios.

Table I. Odds Ratio Estimates (comparing AA vs. C)

Effect	Point Estimate	95% Wald Confidence Limits
Days Since Admission	0.862	0.799 – 0.930
Congestive Heart Failure (0 vs. 1)	0.066	0.007 – 0.625

These results indicate that for each elapsed day since admission, the odds of being transported by AA (relative to being transported by commercial airline) decreases by a factor of 0.862 (when adjusting for the diagnosis of CHF). For example, a patient transported 1 week after admission would have an odds of $(0.862)^7$=0.354 of being transported by AA (vs. C). At 2 weeks after admission, the odds decrease to 0.125.

Furthermore, after adjustment for the number of days since admission, patients without CHF are much less likely to be transported by AA than patients with CHF (odds ratio 0.066). This can be explained by the fact that patients with CHF are likely to be more ill and require the services of an air ambulance.

II. Air Ambulance Transport Post Myocardial Infarction:

1. MI Class - Complicated MI vs. Uncomplicated MI:

In order to evaluate differences between patients with different MI classes, a logistic regression analysis was performed using the 51 patients transported by AA post MI, with MI class (complicated vs. uncomplicated) as the dependent variable. Stepwise model selection (with significance level of 0.15 to enter and 0.25 to stay in the model) was performed using 4 categorical (binary) independent variables (i.e. sex, revascularization procedure prior to transport (yes/no), use of oxygen at time of transport (yes/no), use of intravenous medication at time of transport (yes/no)) and 3 continuous independent variables (i.e. age in years, days since admission, and transport duration in hours).

Following the stepwise procedure only age and oxygen use at the time of transport were retained in the model. Table II gives the point estimates and 95% confidence intervals for the odds ratios.

Table II. Odds Ratio Estimates (comparing Complicated MI vs. Uncomplicated MI)

Effect	Point Estimate	95% Wald Confidence Limits
Age	1.091	1.019 – 1.167
Oxygen Use (0 vs. 1)	0.240	0.059 – 0.973

These results indicate that older patients were more likely to present with complicated MI with the odds of complicated MI increasing by approximately 9% for each year increase in age. Patients with complicated MI were also much more likely to be on oxygen at the time of transportation than patients with uncomplicated MI. This is expected because patients with CHF resulting from a complicated MI are more likely to be hypoxic and require oxygen therapy.

2. Inflight Complications:

In order to determine if any of the factors related to patients' medical status were associated with the incidence of inflight complications, multivariable logistic regression analysis was performed on the 51 patients transported by AA post MI, with inflight complications (presence vs. absence) as the dependent variable.

Stepwise model selection (with significance level of 0.15 to enter and 0.25 to stay in the model) was performed using 5 categorical (binary) independent variables (i.e. sex, revascularization procedure prior to transport (yes/no), use of oxygen at time of transport (yes/no), use of intravenous medication at time of transport (yes/no), and MI class (complicated/uncomplicated)) and 3 continuous independent variables (i.e. age in years, days since admission, and transport duration in hours).

Following the stepwise procedure, the only variable retained in the model was age (odds ratio 0.937, 95% confidence interval 0.867 to 1.037). Thus in this sample of 51 patients with a low incidence of complications (5/51), none of the other potential risk factors were found to be associated with complications.

The finding that increased age appears to decrease the odds of inflight complications is counter-intuitive. This result is likely due to the possibility that physicians might have been more aggressive in transferring younger patients more acutely after their myocardial infarction. This hypothesis is supported by the fact that the observed trend becomes even less apparent after adjusting for days since admission or chest pain free interval (i.e. younger patients with inflight complications were transported sooner after their MI).)

Given that practice guidelines for flight post MI are based on days since MI, it was decided to specifically estimate the effect of days since admission (a proxy for days since MI) on the risk of inflight complications. The above multiple logistic regression analysis was therefore repeated forcing the variable days since admission into the model. Stepwise model selection (with significance level of 0.15 to enter and 0.25 to stay in the model) was performed using the same 5 categorical independent variables and 3 continuous independent variables.

Following the stepwise procedure, no other variables were retained in the model. Table III provides the point estimate and 95% confidence interval for the odds ratio.

Table III. Odds Ratio Estimate (Inflight complication vs. no inflight complication)

Effect	Point Estimate	95% Wald Confidence Limits
Days since admission	0.652	0.374 - 1.136

Although not statistically significant, this finding suggests that patients transported at an increased number of days after admission were less likely to experience an inflight complication.

In order to estimate the effect of chest pain free interval on the risk of inflight complications, the above multivariable logistic regression analysis was repeated forcing the model to include the dummy variables representing chest pain free interval. Stepwise model selection (with significance level of 0.15 to enter and 0.25 to stay in the model) was performed using the same 5 categorical independent variables and 3 continuous independent variables, with instructions to include 2 dummy variables to compare chest pain free intervals of 48-72 hours and >72 hours to the reference category of <48 hours).

Following the stepwise procedure, no other variables were retained in the model. Table IV provides the point estimate and 95% confidence interval for the odds ratio.

Table IV. Odds Ratio Estimate (Inflight complication vs. no inflight complication)

Effect	Point Estimate	95% Wald Confidence Limits
CP free 48-72 hr (0 vs. 1)	4.500	0.310 – 65.233
CP free > 72 hr (0 vs. 1)	8.250	0.898 – 75.789

Although not statistically significant, this model states that patients transported within 48 hours of last chest pain had and odds of experiencing a complication 4.5 times greater than patients transported 48-72 hours after last chest pain, and 8.25 times greater than patients transported >72 hours after last chest pain. Despite the lack of statistical significance, this trend suggests that the odds of experiencing a complication greatly decreases in patients transported at greater intervals after last chest pain.

3. <u>Incidence of Complications – Sample Size Considerations</u>:

In our sample of 51 patients transported by AA post MI, there were 5 minor complications. The incidence of complications was therefore only 9.8%. Assuming that the incidence of complications in a large population of patients transported by AA post MI is 9.8%, then the standard deviation of the sample proportion of complications would be:

Standard Deviation (**SD**)= $\sqrt{[p(1\text{-}p)/n]}$= $\sqrt{[0.098(0.902)/51]}$ = 0.0416

Since the sampling distribution is approximately normal, we can estimate a 95% confidence interval (CI) for the true incidence of complications as:

CI = 9.8 +/- 1.96*SD = 9.8 +/- 1.96(4.2) = 0.0165-0.1795

In order to have had a narrower confidence interval (say, 9.8 +/- 5%), the SD would have had to be 2.55%, which would have required a **sample size of 136 patients**. This is likely to be achievable by accruing patients transported by *Skyservice Lifeguard* over a 3 year interval, assuming the number of post MI patients transported is relatively constant over time.

CHAPTER 6:

Summary and Conclusions

Elective long distance aeromedical transport of cardiac patients occurs with increasing frequency, as a result of medical, economic and social pressures to return a patient to their country or medical system. Despite the benefits of early aeromedical repatriation, there are risks involved in transporting cardiac patients. These risks are related to the adverse effects of hypoxia (low oxygen saturation in blood) at altitude, the effects of anxiety about flying, and the potential for complications related to movement of the patient.

Although there are some data pertaining to short distance and emergency aeromedical transport of cardiac patients, this research is the first published work concerning elective long distance air ambulance transport of cardiac patients. Currently, there are no formal guidelines for air ambulance transport of cardiac patients. The current guidelines of the ACC/AHA, AsMA, and AMA concern unescorted commercial air travel only.

Given the paucity of data and the absence of specific guidelines, the objectives of this thesis research were to examine the safety of elective aeromedical transport of cardiac patients in general, to study the safety of elective air ambulance transport of cardiac patients post myocardial infarction in particular, and to suggest a timeframe for safe air ambulance transport post myocardial infarction (MI).

A retrospective study of all long distance aeromedical transports performed by the Montreal based *Skyservice Lifeguard* medical transport service during the period 98/1/1 to 98/10/1 identified 109 patients with cardiac diagnoses. Of these 109 patients, 83 were transported by Lear Jet 35 air ambulance (AA), and 26 commercially (C). Patients were transported by AA sooner (7 vs. 13.7 days post admission on average) and with fewer invasive procedures done prior to transport (27% vs. 50%), than those transported by C. Multiple logistic regression also identified congestive heart failure as a predictor for transport by AA rather than C. All aeromedical transports were accomplished safely, without any major complications. There was a small increase in incidence of minor complications in AA patients (10% vs. 4%), that were all easily treated by onboard personnel.

Of the 109 cardiac patients, there were 51 patients transported by AA post MI. Of these 51 patients, 26 were classified as having had a complicated MI (Killip Class II-IV) and 25 were classified as having had an uncomplicated MI (Killip Class I). The incidence of minor complications was 5/51 (~10%), and all occurred in patients that were transported within 7 days of admission. The incidence of minor complications in patients transported with chest pain free interval of <48 hours, 48-72 hours, and >72 hours, was 33%, 9%, and 6% respectively. Patients with uncomplicated MI transported by day 3 post admission had an incidence of complications of 13% compared to 50% for complicated MI. Patients transported on days 4-7 had an incidence of complications of 9% vs. 14% for uncomplicated and complicated MI groups respectively. A trend for increased risk of minor complications in patients transported earlier (i.e. fewer days after admission and shorter chest pain free interval) was also suggested by logistic regression analysis.

In considering chest pain free interval, it should be noted that *Skyservice Lifeguard*'s guidelines (Appendix 4) generally require 48 hours chest pain free post

MI for elective aeromedical transportation. The 6 patients transported within 48 hours may have been transferred on a more urgent basis, and may therefore not be representative of patients undergoing elective transport. Among patients transported 48-72 hours post last chest pain, one complication occurred in the complicated MI group while none occurred in the uncomplicated MI group. The complication rate in post MI patients transported >72 chest pain free was 6% with no significant difference between complicated and uncomplicated MI groups.

This study is limited by the fact that it is a case series of a heterogeneous patient population selected by retrospective chart analysis. Although the charts were well documented, it is impossible to ascertain the accuracy of all reported data. Electrocardiograms and blood tests (e.g. cardiac enzymes), which would have been useful in objectively ruling out cardiac ischemia and/or infarction, were not available. The modest sample size and low incidence of complications limit the statistical power of the study, especially in subgroup analysis.

Nevertheless, the data suggest that elective AA transport of patients post MI may be safely accomplished 3-7 days post admission or after 48-72 hours chest pain free, with a low incidence of easily reversible minor complications. Transport may be considered sooner when adequate medical care, including urgently needed invasive procedures, is unavailable locally.

Future research using larger prospective studies is needed to better define criteria for safely transporting cardiac patients by air ambulance. Guidelines for aeromedical transport of cardiac patients post MI must be established, and should distinguish between C and AA transport.

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APPENDIX 1

Letter permitting inclusion of published manuscript

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January 29, 2001

Dear Dr. Essbag,

Concerning your letter of January 15, 2001, regarding permission to include the following article as part of your thesis:

Essebag V, Lutchmedial S., Churchill-Smith M. Safety of long distance aeromedical transport of the cardiac patient: a retrospective study. Aviat Space Environ Med 2001; 72:182-187.

Permission is hereby granted, provided credit is given source.

Sincerely,

Pamela Day
Managing Editor

APPENDIX 2

Published Manuscript

Safety of Long Distance Aeromedical Transport of the Cardiac Patient: A Retrospective Study

VIDAL ESSEBAG, M.D., SOHRAB LUTCHMEDIAL, M.D., FRCP(C), AND MICHAEL CHURCHILL-SMITH, M.D., FRCP(C)

ESSEBAG V, LUTCHMEDIAL S, CHURCHILL-SMITH M. *Safety of long distance aeromedical transport of the cardiac patient: a retrospective study.* **Aviat Space Environ Med 2001; 72:182–7.**

Background: The purpose of this study is to provide data regarding the safety of long distance air transport of cardiac patients, establish a time frame for safe transport, and assess current guidelines for postmyocardial infarct (post-MI) transport. ***Methods:*** Retrospective analysis of all long distance aeromedical transports performed by Montreal-based *Skyservice Lifeguard* from January 1 to October 1, 1998. ***Results:*** 109 cardiac patients were transported; 83 by air ambulance (AA), and 26 commercially (C). Diagnoses included MI (63%), unstable angina (31%), congestive heart failure (21%), and arrhythmia (17%). Patients were transported a mean of 7 d (AA) vs. 13.7 d (C) after presentation. Inflight complications, occurring in 10% of AA and 4% of C flights, were minor (chest pain, desaturation, and hypotension), and resolved quickly. In 51 post-MI AA patients, complication rate for transport > 7 d after admission was 0% (vs. 14% <7 d), and > 72 h after last chest pain was 6% (vs. 18% <72 h). Comparing uncomplicated (n = 25) vs. complicated (n = 26) MI reveals fewer complications for transport 0–3 d (13% vs. 50%) and 4–7 d (9% vs. 14%) after admission, and 48–72 h after last chest pain (0% vs. 100%). ***Conclusions:*** AA transport of cardiac patients can safely be performed earlier than guidelines for C flights. AA transport appears safe after complicated MI by day 7 or > 72 h chest pain free, and after uncomplicated MI by day 3 or > 48 h chest pain free. Future guidelines for aeromedical transport post-MI should distinguish between C and AA.

Keywords: medevac, air ambulance, air evacuation, aeromedical transport, cardiac transport, patient transport, myocardial infarction, unstable angina.

AEROMEDICAL REPATRIATION of cardiac patients hospitalized internationally has increased significantly in the past decade, for a combination of medical, social and economic reasons. This has been facilitated by the advent of fixed wing aircraft equipped to function as intensive care units for long distance aeromedical transportation.

Despite the benefits of early repatriation, there are potential risks involved in the aeromedical transport of cardiac patients. These include the physiological effects of hypoxia and neuroendocrine activation that may result in ischemia or arrhythmia (2), the mental effects of transport-related anxiety (8), and the possibility of physical injury related to movement of patients. However, data documenting the frequency of such complications during long-distance high-altitude flight are lacking.

The majority of data on aeromedical transportation of cardiac patients come from short-distance helicopter medevac flights to transport patients from rural settings for reperfusion techniques like thrombolysis or angioplasty following acute myocardial infarction (MI). Five major reports describe the aeromedical transfer of patients early in the course of acute MI (4,9,11,13,14). The data suggest that such transport is safe, based on the absence of in-flight deaths or significant morbidity. The most frequent in-flight problems were non-fatal hypotension and arrhythmias, managed by onboard medical personnel equipped with intravenous fluids, antiarrhythmics, thrombolytics, and nitroglycerin.

Fixed wing aircraft have generally been reserved for the long distance transport of stabilized cardiac patients, days or weeks after their acute presentation. Such transport can be performed by commercial airline (C) or specialized fixed wing air ambulance (AA).

The current guidelines regarding long distance flight and cardiac patients concern commercial airline travel. The American College of Cardiology (ACC) and American Heart Association (AHA) recommend that following uncomplicated MI, stable patients (without fear of flying) may travel by air within the first 2 wk, provided they are accompanied by companions, carry sublingual nitroglycerin, and request airport transportation to avoid rushing (12). Patients who are unstable, symptomatic, or who experienced a complicated MI [requiring CPR, experiencing hypotension, serious arrhythmias, high-degree block, or congestive heart failure (CHF)], are recommended to wait a period of at least 2 wk following stabilization before commercial air travel. The guidelines of the Aerospace Medical Association (AsMA) state that unescorted commercial airline flight is contraindicated within 3 wk of uncomplicated MI,

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This manuscript was received for review in June 2000. It was revised in September 2000. It was accepted for publication in October 2000.

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ithin 6 wk of complicated MI, within 2 wk of coronary tery bypass graft (CABG), or within 2 wk of cerebro-ascular accident (CVA) (1). Other cardiovascular con-aindications to commercial airline flight include unsta-le angina, severe decompensated CHF, uncontrolled ypertension, uncontrolled ventricular or supraventricu-ır tachycardia, Eisenmenger's syndrome, and severe ymptomatic valvular heart disease. The American Med-al Association (AMA) guidelines indicate that travel y commercial aircraft is contraindicated within 4 wk fter MI, within 2 wk after CVA, and for anyone with evere hypertension or decompensated cardiovascular isease (3).

With the advent of fixed wing air ambulances quipped with intensive care facilities, cardiac patients re being transported earlier than these recommenda-ions for commercial air travel. Although it seems rea-onable that patients could be safely transported more cutely under these circumstances, there are no estab-ished peer-reviewed guidelines at the present time re-arding transport of cardiac patients by fixed-wing air mbulance.

METHODS

A retrospective analysis was performed of all long dis-ance aeromedical transports performed by the Montreal ased *Skyservice Lifeguard* medical transport service dur-ing the period January 1 to October 1, 1998. All files were carefully reviewed searching for patients with cardiac di-agnoses including myocardial infarction, unstable angina, arrhythmia, and congestive heart failure. A total of 109 patients with cardiac diagnoses were identified, and all were included in the study. Preflight evaluations and inflight medical assessments were available for all patients on standardized *Skyservice Lifeguard* forms.

Using *Filemaker Pro* software, a database form was prepared in order to record all pertinent data collated from these preflight evaluations and inflight assess-ments. In particular, data were collected regarding age and sex; in-hospital diagnoses and procedures, includ-ing postprocedure intervals; type of flight (air ambu-lance vs. commercial); status at the time of transport including days since admission, chest pain free interval, ground oxygen use, intravenous medications, and me-chanical ventilation; duration of transportation; and de-tails of inflight complications including interventions and outcomes.

Skyservice Lifeguard is a Montreal-based company that provides aeromedical repatriation services nationally and internationally, to and from countries spanning most of the globe. Preflight evaluations are initially performed by telephone from Montreal prior to making transport arrangements. The decision to transport the patient depends on a subsequent evaluation (including history, physical examination, and review of chart and investigation results) performed on site by the flight physician and/or nurse prior to transportation. Al-though cases are assessed individually, *Skyservice Life-guard* has general guidelines for elective aeromedical transport of cardiac patients. Patients with unstable angina should be pain free for at least 24 h. Patients with MI should be pain free for at least 48 h. Patients should be free of hemodynamically unstable arrhyth-mias for at least 24 h. Postprocedure intervals for pace-maker, angiography, percutaneous transluminal angio-plasty (PTCA), and CABG, should be at least 12, 12, 24 and 72 h, respectively.

Data are reported as percentages. Differences be-tween patients transported by AA and C with respect to in-hospital diagnoses and procedures and status at time of transportation were assessed using χ^2 tests on counts (see Tables I and II). Patients with MI were examined separately and differences in procedures and clinical status between uncomplicated MI (Killip I) and compli-cated MI (Killip II-IV) patients were also analyzed using χ^2 tests (see Table IV). To examine the possible modi-fying effect of the timing of transport on the risk of complications in the Killip I and Killip II-IV patients, a stratified analysis was carried out. A χ^2 test assessing the differences in complication risk in Killip I patients vs. Killip II-IV patients was performed for each level of days since admission and chest pain free interval (see Table V). All p values were rounded to the nearest thousandth. Values of $p < 0.05$ were considered statis-tically significant.

TABLE I. IN HOSPITAL DIAGNOSES AND PROCEDURES.

Diagnoses & Procedures	Combined (n = 109)	Air Ambulance (n = 83)	Commercial (n = 26)	p Value
Diagnoses				
Unstable Angina	31%	29%	38%	0.359
MI (total)	63%	61%	69%	0.472
Killip I	36%	30%	54%	0.034*†
Killip II	5%	5%	4%	
Killip III	15%	17%	8%	
Killip IV	8%	10%	4%	
CHF	21%	24%	12%	0.171
Arrhythmia	17%	20%	8%	0.134
Procedures				
Revascularization (total)	17%	10%	38%	<0.001*
CABG	6%	2%	19%	0.002*
PTCA	10%	7%	19%	0.076
Cath‡	11%	13%	4%	0.181
Pacemaker	4%	4%	4%	0.956
Intubation§	9%	11%	4%	0.181
Thrombolysis	12%	13%	8%	0.445

* Statistically significant difference between Air Ambulance and Commercial ($p < 0.05$).
† Comparison between Killip I MI and Killip II–IV MI.
‡ Patients who had a Cath but no PTCA or CABG prior to transport.
§ Excluding intubations required for surgery.

RESULTS

During the study period, 109 admitted patients with cardiac diagnoses underwent long distance aeromedi-cal transportation; 83 by Lear Jet 35 air ambulance (AA), and 26 commercially (C). The study population con-sisted of 81 males and 28 females. The mean age of males was 65.7 yr (range 33–89), and the mean age of females was 71.3 yr (range 47–87).

In these 109 patients with at least one cardiac diag-nosis, the frequency of myocardial infarction, unstable angina, CHF, and arrhythmia, was 63%, 31%, 21%, and 17%, respectively (**Table I**). Although the frequency of

TABLE II. STATUS AT TIME OF TRANSPORTATION.

Status at Time of Transportation	Combined (n = 109)	Air Ambulance (n = 83)	Commercial (n = 26)	p Value
Days since admission				
0–3	21%	28%	0%	0.003*
4–7	39%	46%	19%	
8–14	23%	17%	42%	
>14	17%	10%	38%	<0.001*
≤7	61%	73%	19%	<0.001*
Chest pain free interval				
<24 hours	4%	5%	0%	0.254
24–48 hours	8%	11%	0%	
48–72 hours	18%	22%	8%	
≤72 hours	30%	37%	8%	0.004*
No chest pain	7%	8%	4%	0.434
IV medications				
Heparin	29%	39%	0%	<0.001*
Nitroglycerin	16%	20%	0%	0.012*
Vasopressors†	6%	7%	0%	0.158
Antiarrhythmics‡	5%	6%	0%	0.200
Intubated	2%	2%	0%	0.424
O_2 use on ground	32%	42%	0%	<0.001*

* Statistically significant difference between Air Ambulance and Commercial ($p < 0.05$).
† Four patients on dopamine alone, and two patients on both dopamine and dobutamine.
‡ Four patients on lidocaine alone, and one patient on both procainamide and amiodarone.

MI was similar in the AA and C groups (61% vs. 69%), the proportion of MIs that were uncomplicated (Killip I) was greater in the C (14 of 18 MIs) than in the AA (25 of 51 MIs) group ($p = 0.034$). Revascularization procedures (PTCA or CABG), performed prior to transportation in 17% of the total group, were more common in the C (38%) than the AA (10%) group ($p < 0.001$).

Patients in the AA group were transported earlier with 73% of AA group vs. 19% of C group transported within 7 d of admission ($p < 0.001$) (**Table II**). AA patients were transported at a mean of 7 d postadmission vs. 13.7 d for C patients. Significantly more patients were transported greater than 2 wk postadmission by C ($p < 0.001$). Transportation was undertaken within 72 h of last chest pain in 37% of AA vs. 8% of C patients ($p = 0.004$). At the time of transport of AA patients, treatment at local hospital included oxygen (in 42% of patients), intubation and mechanical ventilation (2%), heparin (39%), nitroglycerin (20%), vasopressors (7%), and antiarrhythmics (6%). None of the C patients were on oxygen (on ground) or intravenous medications. The mean duration of transportation was 6.4 h for AA patients and 11 h for C patients.

There were no major inflight complications (i.e., death, myocardial infarction, or failure to complete transport). Minor inflight complications occurred in 9/109 (8%) of patients; 8/83 (10%) AA patients, and 1/26 (4%) of C patients. The minor complications consisted of chest pain in 6 patients, desaturation (saturation < 91% with or without symptoms) in 2 patients, and hypotension (systolic BP decrease by > 15 mmHg requiring introduction or increase of vasopressor) in 1 patient. All minor inflight complications resolved after treatment with onboard medications, and did not result in any significant morbidity (**Table III**).

To address the specific question of the safety of long distance air ambulance transport post-MI, we sepa-

TABLE III. COMPLICATIONS DURING TRANSPORT.

Type of Transport	Age & Sex	Hosp Diagnoses & Procedures	Status at Time of Transportation	Duration of Transport	Complications	Interventions and Outcome
AA	44M	UA, MI (Killip II)	4d post adm, CP free <24 h, 2L O_2, IV Heparin	5 h	Chest pain inflight	Resolved after NTG spray ×2, ↑ O_2, lasix
AA	54M	MI, (Killip I) Thrombolysis	5d post adm, CP free >72h, 2L O_2, IV Hep	3 h	Chest pain ×1 inflight, ×1 on ground	Each resolved with NTG spray ×1
AA	68F	MI, (Killip III) Arrhythmia (VT)	2d post adm, CP free >48 but <72h, no O_2, IV Hep	6 h	Chest pain inflight	Resolved with NTG spray ×1 and morphine
AA	47F	MI, (Killip I) Thrombolysis	2d post adm, CP free <24h, 4L O_2, IV Hep + NTG	3 h	Chest pain inflight	Resolved after ↑ NTG
AA	82M	MI, (Killip III) CHF	5d post adm, CP free >72h, no O_2	7 h	Desaturation inflight	Resolved with ↑ O_2
AA	67M	UA	4d post adm, CP free >48h but <72h, 2L O_2, IV Hep + NTG	5 h	Chest pain inflight	Resolved with 2mg IV morphine
AA	75M	Arrhythmia (Afib)	5d post adm, no CP, no O_2	5 h	Desaturation inflight	Resolved with ↑ O_2 and lasix
AA	71M	CHF	46d post adm, CP free >72h, 8L O_2, IV dopamine	9 h	Hypotension inflight	Resolved after ↑ dopamine
C	73M	UA	9d post adm, CP free >72h, no O_2, refused cath	10 h	Chest pain inflight	Resolved with O_2 and NTG spray ×3

AA, air ambulance; C, commercial airline; M, male; F, female; UA, unstable angina; MI, myocardial infarction; VT, ventricular tachycardia; CHF, congestive heart failure; Afib, atrial fibrillation; d, days; CP, chest pain; O_2, oxygen; IV, intravenous; Hep, heparin; NTG, nitroglycerin.

TABLE IV. POST MI PATIENTS TRANSPORTED BY AIR AMBULANCE.

Status at Time of Transportation	All MI (n = 51)	Complicated MI (n = 26)	Uncomplicated MI (n = 25)	p Value
Procedures Done				
CABG	4%	4%	4%	0.977
PTCA	12%	4%	20%	0.073
Cath†	14%	15%	12%	0.725
Pacemaker	4%	8%	0%	0.157
Intubation	6%	12%	0%	0.080
Thrombolysis	22%	12%	32%	0.076
Days since admission				
0–3	20%	8%	32%	0.029*
4–7	49%	54%	44%	
>7	31%	38%	24%	0.266
Chest pain free interval				
<24 hours	6%	4%	8%	0.529
24–48 hours	6%	8%	4%	
48–72 hours	22%	4%	40%	
≤72 hours	33%	15%	52%	0.006*
IV medications				
Nitroglycerin	25%	15%	36%	0.091
Heparin	37%	31%	44%	0.329
Vasopressors‡	8%	15%	0%	0.041*
Antiarrhythmics§	6%	12%	0%	0.080
O_2 use on ground				
None	65%	54%	76%	0.099
>4 L	4%	8%	0%	0.157

* Statistically significant difference between complicated & uncomplicated MI ($p < 0.05$).
† Patients who had a Cath but no PTCA or CABG prior to transport.
‡ Three patients on dopamine alone, and one patient on both dopamine and dobutamine.
§ Two patients on lidocaine alone, and one patient both amiodarone and procainamide.

rately analyzed the group of 51 patients transported by AA post-MI: 26 patients with complicated MI (Killip II-IV), and 25 patients with uncomplicated MI (Killip I) (Table IV). Of the 51 patients, 30% had Cath, PTCA or CABG prior to transport. Transportation occurred within 14 d for 87%, within 7 d for 69%, and within 3 d for 20%. Chest pain free interval was less than 72 h for 33%, less than 48 h for 12%, and less than 24 h for 6%. Patients with uncomplicated MI were transported sooner than those with complicated MI: average of 6.3 vs. 9.6 d postadmission. Also, transportation within 72 h of last chest pain occurred in 52% of uncomplicated MIs vs. 15% of complicated MIs ($p = 0.006$).

While there were no major complications, minor complications occurred in 5 of 51 post-MI patients, the details of which are described in Table III (the first 5 patients). The frequency of minor complications in subgroups of patients divided according to time of transportation (days since admission) and chest pain free interval is detailed in Table V. Complications occurred in 14% (5/35) of patients transported 0–7 d post-MI vs. 0% (0/16) of patients transported > 7 d post-MI. Complications occurred in 18% (3/17) of patients transported within 72 h of last chest pain vs. 6% (2/34) of patients transported > 72 h after last chest pain.

Comparison of complicated and uncomplicated MI groups suggests a difference in incidence of minor complications (Table V). For patients transported at 0–3 d postadmission, incidence of complications in uncomplicated MI patients was 13% vs. 50% for complicated MI. Patients transported at 4–7 d had incidences of 9% vs. 14% for uncomplicated and complicated MI groups, respectively. In patients transported 48–72 h after last chest pain, a complication occurred in the complicated MI group but not in the uncomplicated MI group.

TABLE V. COMPLICATIONS IN POST MI PATIENTS TRANSPORTED BY AIR AMBULANCE.

Subgroups	All MI (n = 51)	Complicated MI (n = 26)	Uncomplicated MI (n = 25)	p Value
Days since admission				
0–3	2/10 (20%)	1/2 (50%)	1/8 (13%)	0.236
4–7	3/25 (12%)	2/14 (14%)	1/11 (9%)	0.692
>7	0/16 (0%)	0/10 (0%)	0/6 (0%)	
Chest pain free interval				
<48 hours	2/6 (33%)	1/3 (33%)	1/3 (33%)	1
48–72 hours	1/11 (9%)	1/1 (100%)	0/10 (0%)	0.001*
>72 hours	2/34 (6%)	1/22 (5%)	1/12 (8%)	0.654
Total	5/51 (10%)	3/26 (12%)	2/25 (8%)	0.671

* Statistically significant difference between complicated and uncomplicated MI ($p < 0.05$).

DISCUSSION

Modern day air ambulances have true intensive care capabilities, allowing transport of critically ill patients. Compact technology exists to analyze blood gases and electrolytes during flight, compact mechanical ventilators, and all forms of intravenous medications are at the disposal of the flight physician. There are often medical, economic and social pressures to return a patient to their country or medical system, but these must be weighed against the possible risks of long distance aeromedical transport.

There are few published studies of long distance aeromedical transport of cardiac patients. In a recent study of 196 commercially transported patients 3–53 d post-MI (7), the majority (77%) of patients were flown between days 8–21 post-MI. There were only 9 incidents requiring physician intervention, 6 of which occurred in the patients transported less than 14 d post-MI. Four of these six incidents can be classified as cardiac, and each resolved after physician intervention.

The long distance transport of active cardiac patients by fixed wing air ambulance is documented in three studies. One study describes 11 patients in cardiogenic shock (on intravenous inotropic support, 8 requiring intra-aortic balloon pumps), transported a median of 1160 mi: 6 patients by air ambulance, and 5 by ground ambulance (10). All patients survived the transport without any medical complications of travel. A second study detailed the airlift of 7 military personnel after acute myocardial infarction (6). The patients were transported within 7 d of symptom onset, after thrombolysis and at least 24 h of hemodynamic stability. Transportation time ranged from 4.4 to 12.2 h, and there were no complications. A third study reports the transoceanic air evacuation of 59 patients with unstable angina requiring care not locally available (5). Inflight information available for 31 patients revealed only minor inflight complications in 6 patients. Review of inpatient records at receiving hospitals confirmed significant coronary artery disease in the majority of patients, and the absence during admission of complications attributable to aerovac transfer.

The current guidelines of the ACC/AHA, AsMA, and AMA, as mentioned in the introduction, concern commercial air travel. Given the paucity of publications about long distance aeromedical transport of cardiac patients, and the absence of specific guidelines for fixed wing AA transport, this study was undertaken to provide data regarding the safety of AA transport, and to aid in establishing guidelines for AA transport.

In this study of 109 cardiac patients (83 AA and 26 C), patients were transported by AA sooner (7 vs. 13.7 d postadmission on average) and with fewer invasive procedures done prior to transport (27% vs. 50%), than those transported by C. This was accomplished safely, without any major complications, and with only a slightly greater incidence of minor complications (10% vs. 4%), all of which were easily resolved with onboard management.

In the subanalysis of 51 post-MI patients (26 complicated and 25 uncomplicated MI) transported by AA, minor complications occurred in 10% of patients, all of whom were transported within 7 d of admission. The incidence of minor complications in patients transported with chest pain free interval of < 48 h, 48–72 h, and > 72 h, was 33%, 9%, and 6%, respectively. Patients with uncomplicated MI transported by day 3 postadmission had an incidence of complications of 13% compared with 50% for complicated MI. Patients transported on days 4–7 had an incidence of complications of 9% vs. 14% for uncomplicated and complicated MI groups, respectively. In considering chest pain free interval, we can only focus on patients transported chest pain free > 48 h because *Skyservice Lifeguard*'s guidelines (see Methods) generally require 48 h chest pain free post-MI for elective aeromedical transportation. The 6 patients transported within 48 h are likely to have been transferred on a more urgent basis, and are, therefore, not representative of patients undergoing elective transport. In patients transported 48–72 h after last chest pain, one complication occurred in the complicated MI group while none occurred in the uncomplicated MI group. The complication rate in post-MI patients transported > 72 h chest pain free was 6% with no significant difference between complicated and uncomplicated MI groups.

This study is limited by the fact that it is a case series of a heterogeneous patient population selected by retrospective chart analysis. Although the charts were well documented, it is impossible to ascertain the accuracy of all reported data. The sample size and small number of events limit the statistical power of the study, especially in subgroup analysis. There is also no follow up to rule out the possibility of delayed effects of aeromedical transport, although a previous study (5) suggests the absence of delayed complications attributable to long distance aeromedical transport of patients with acute coronary syndromes.

The data presented in this study suggest that elective AA transport of patients after complicated MI may be safely accomplished by day 7 postadmission or after 72 h chest pain free, with a low incidence of easily reversible minor complications. For patients after uncomplicated MI, the study suggests the safety of transportation by day 3 postadmission or after 48 h chest pain free, again with a low incidence of easily reversible minor complications. Transport may be considered sooner when adequate medical care, including urgently needed invasive procedures, is unavailable locally.

Further studies are needed to properly examine the relevant risk factors involved in long distance repatriation, and to identify the patient populations suitable to fly. Databases of prior flights should be archived and inflight complications scrutinized to identify potentially reversible precipitants. Well-designed prospective studies are needed to better define criteria for safely transporting cardiac patients by air. Future guidelines for aeromedical transport of cardiac patients must distinguish between commercial and air ambulance transport.

ACKNOWLEDGMENTS

We would like to thank Dr. Christina Wolfson of the Department of Epidemiology and Biostatistics, McGill University, Montreal, Canada, for reviewing the statistical analyses in this manuscript.

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APPENDIX 3

Filemaker Pro Data Sheet

SKY SERVICE – CARDIAC TRANSPORT RETROSPECTIVE PATIENT DATA SHEET

neral Information

First Name

Sex ◯ Male ◯ Female

Last Name

Age

Admittance Diagnosis

Admission Date

Cardiac Risk Factors

Origin City

Destination City

Origin Hospital

Destination Hospital

Origin Country

ght Information

Departure from Origin Hospital

Date (mm/yy)

Time (hh:mm)

Formal/Written Pre-flight evaluation ◯ Yes ◯ No

Flight Type ◯ Air Ambulance ◯ Commercial

Arrival at Destination Hospital

Date (mm/yy)

Time (hh:mm)

Flight Crew ☐ Medic ☐ RN ☐ MD

Flight Duration Time

Details Medical Conditions

Painfree Interval

Post-proceedure Interval

MI Class

IV Meds ◯ Yes ◯ No

IV Meds Details

Pre-flight O2

In-flight Complications ◯ Yes ◯ No

Ground Saturation

Details In-flight Actions

Air Saturation

Additional O2 In-air

APPENDIX 4

Skyservice Lifeguard Guidelines

Skyservice Lifeguard
Cardiac guidelines for repatriation

General guidelines:

Clinical stability of the patient is the foremost criteria for eligibility for transport. The following classifications of cardiac disease are not exhaustive, and are only meant to guide appropriate clinical evaluations. Should mitigating circumstances warrant, more critically ill or unstable patients could be transported; however the avoidance of hypoxic, ischemic and arrythmic complications during the flight should be the goal of a proper preflight medical clearance.

Preflight electrocardiograms (EKG) and X rays obtained the day of transport can be invaluable should complications arise in the air. EKG findings in cardiac disease are dynamic, making a recent EKG tracing for comparison essential.

Table of contents

1. Unstable angina
2. Uncomplicated MI
3. Complicated MI
4. Post procedural guidelines
5. Supraventricular arrythmias
6. Bradycardias
7. Valvular disease
8. Ischemia during medivac

1. **Unstable Angina**

   Myocardial infarction ruled out by EKG, cardiac enzymes, radiologic tests (echo, cath)

   A. Low Risk
   - Patient should be appropriately and promptly treated (O2, heparin, ASA, nitrates) and pain-free x 24 hours prior to transport.
   - Start to consider transport at 12-24 hours post-admission

   B. High Risk
   - Criteria include hemodynamic changes with pain, pulmonary edema, S3 on auscultation, ST segment shifts > 1 mm with pain, or ongoing pain despite adequate medical therapy.
   - Consideration to angiography should be made prior to transport. High risk criteria correlate with adverse clinical outcomes of death and MI

2. **Uncomplicated MI**

Absence of recurrent angina, significant arrythmias or mechanical complications

A. In the first 48 hours there are the highest risks of significant ventricular arrythmias (5%), recurrent ischemia (5-10%) and mortality. Therefore it is optimal to wait 48 hours before transport

B. The distinction between Q and non-Q wave MI's is less distinct in modern thinking. Q wave MI's have higher in-hospital mortality, but their overall prognosis equalizes in the months following the index event.

C. Mortality is related most strongly to ventricular function, and clinically can be related to the Killip class of MI (derived on initial presentation to hospital)

4. The following data was obtained before the thrombolytic and angioplastic eras, but can still be used as a guideline to relative severity of the infarct

Killip 1: no pulmonary edema, no S3	3% inhospital mortality
Killip 2: mild crackles in lung bases	6%
Killip 3: crackles above 1/2 lung field or an S3	20%
Killip 4: Hemodynamically unstable	> 50%

3. **Complicated MI**

Recurrent angina, mechanical complications, clinically significant arrythmias

A. *Recurrent angina*
- Associated with a high risk of recurrent MI and mortality. Should strongly consider angiography if pain is refractory to medical therapy (discuss with Medical Director)
- If transported, a 48 hours pain free period prior to transport is optimal. Should be transferred on O2, IV heparin +/- NTG drip.

B. Mechanical complications
- These include ventricular septal defect, ventricular rupture, ischemic mitral regurgitation and papillary muscle rupture.
- These are highly significant complications which generally occur within 4-5 days of MI and result in severe hemodynamic instability.
- These patients should not be transported prior to definitive treatment - important to discuss situation with Medical Director
- CHF generally occurs as a function of reduced systolic function, but is not as high a risk complication as the others listed above

C. Arrythmic complications of MI

- *Atrial*

  ➢ Associated with increased morbidity but not mortality. Not a marker for treatable lesion. Can be transported - see specific atrial arrythmia section

- *Junctional*

  ➢ Common post thrombolysis, possibly a marker for successful reperfusion. If stable can be flown with careful observation.
  ➢ If hemodynamically unstable, defer flight until definitive treatment (atropine, pacing, or occasionally antiarrythmics class IA, IC, III), and keep patient stable x 24 hours prior to transport

- *Ventricular*

  ➢ PVC's very common, treatment with lidocaine does not alter prognosis

- *Non sustained VT*

  ➢ (Duration less than 30 seconds, no hemodynamic instability) also common early post MI, a marker for depressed ejection fraction.
  ➢ If frequent (> 5 episodes per day after the first 24 hours) consider angiography or noninvasive risk assessment prior to transport.
  ➢ If infrequent, can be transported if otherwise well. Prophylactic lidocaine is of no benefit.

- *Sustained VT, Vfib*

  ➢ Most frequent early (<24 - 48 hours) post MI. *In this circumstance, it is not a marker for adverse outcomes if the patient survives the 48 hour mark*
  ➢ If it occurs after 48 hours post event, is a marker of depressed ejection fraction and likely of recurrent ischemia.
  ➢ If it occurs after 48 hours post MI, strong consideration for angiography and definitive treatment should be given prior to transport.
  ➢ Treatment with antiarrythmics likely of benefit (beta blockers if not contraindicated, amiodarone IV/PO) and a 24-48 hour period arrythmia free period prior to departure strongly reccomended.

- *Bradycardias*

  ➢ Sinus bradycardia, Type I and II AV blocks typically transient and only require therapy if symptomatic
  ➢ Type III / complete AV block occurs in 5-15% of patients with MI. Along with left bundle branch block and bifasicular block is a frequent indication for a temporary pacemaker.
  ➢ *Follow recommendations in section 6*

4. Post procedural guidelines

A. Angiography

- Safe to transport 12-24 hours post procedure. Most complications occur within 6-8 hours

B. PTCA Uncomplicated:

- Safe to transport after 12-24 hours

C. PTCA Complicated:

- (Recurrent angina / dissection / post procedure MI)
- Consider 24-48 hour observation with 12-24 hour reassessments due to the possibility that patient may require repeat angiography

D. CABG/Valve

- If uncomplicated, safe to transport after 72 hours with chest tubes in place. Consider low-altitude flight.
- Obtain pre-flight EKG and Xray.
- If complicated by arrythmia, ischemia, other surgical complications, cases should be evaluated on an individual basis

E. Permanent Pacemaker:

- Safe for transport by 12-24 hours once pacemaker function verified and pneumothorax ruled out.

F. Implantable defibrillator:

- Safe for transport by 24-36 hours once defibrillator function verified and pneumothorax ruled out.

5. Supraventricular arrythmias

The following arrythmias are more commonly seen in patients with structural heart disease, and can be precipitated by pain, fever, infection, electrolyte abnormalities, ETOH, thyrotoxicosis and ***hypoxia.*** *First line therapy should be elimination of these precipitating factors.*

A. Atrial Fibrillation/Flutter

- Stable *No CI to flight*
- Paroxysmal *No CI to flight*
- Unstable
  - ➢ Patient should be stabilized (ideally in sinus rhythm) at referring hospital with drug therapy or DC cardioversion
  - ➢ Drug therapy includes class IA, IC and class III antiarrythmics
  - ➢ Ideally, patient should be free of hemodynamically unstable arrythmias for 24 hours prior to transport

➢ Ensure easy access to defibrillator should unstable rhythms recur in flight.

B. Supraventricular arrythmias
- AV nodal reentry, atrial reentry, WPW tachycardias
- If stable with the arrythmia, can be transported
- If unstable with the arrythmia, suppressive drug therapy or definitive treatment with radiofrequency ablation should be considered before transport

C. Sinus Arrythmia *No CI to flight*

D. Atrial Tachycardia
- Symptoms relate to heart rate - can rarely become unstable hemodynamically
- If unstable, defer flight until definitive treatment with antiarrythmics (Beta blockers, Ca blockers, Digoxin) keep patient stable x 24 hours
- Rule out digoxin toxicity as a *cause* of this arrythmia

E. Premature Atrial Complexes *No CI to flight*

F. Junctional tachycardia
- If stable can be flown with careful observation
- If unstable, defer flight until definitive treatment with antiarrythmics (class IA, IC, III drugs) or pacing/ chronotropic agents; keep patient stable x 24 hours

6. Bradyarrythmias

A. Symptoms with bradyarythmia *of any type*
- Place transcutaneous pacemaker prior to transport and ensure that leads capture.
- Consider transvenous pacemaker if patient is obese or has COPD as transcutaneous pacemaker may not be reliable

B. Sinus bradycardia; asymptomatic *No CI to flight*

C. 1st and 2nd degree *(asymptomatic)* *No CI to flight*

D. 2nd degree *(symptomatic)*:
- Place transcutaneous pacemaker prior to transport and ensure that leads capture.
- Consider transvenous pacemaker if patient is obese or has COPD as transcutaneous pacemaker may not be reliable

E. Any 3rd degree block
- Place transcutaneous pacemaker prior to transport and ensure that leads capture.
- Consider transvenous pacemaker if patient is obese or has COPD as transcutaneous pacemaker may not be reliable

7. Valvular disease

The majority of admissions relating to valvular disease relate to the following diagnoses: heart failure, syncope (typically exertional), arrythmia, angina and infection/endocarditis

The majority of these conditions have been described elsewhere in these guidelines, specific issues will be discussed below.

A. Aortic Stenosis
- Pressure overload on the left ventricle, without treatment can lead to angina, syncope, arrythmias and heart failure
- Symptoms can be temporarily minimized for transport by bedrest, oxygen and if necessary, small doses of diuretics
- Vasodilating drugs should be avoided as the cardiac output is fixed and systemic hypotension may result

B. Aortic Regurgitation / Mitral Regurgitation
- Volume overload on the left ventricle
- Can lead to ventricular dilatation and failure
- Therapy includes ACE inhibition/afterload reduction and diuretics

C. Mitral Stenosis
- Leads to increased left atrial and pulmonary venous pressures - dyspnea, hemoptysis, pulmonary edema, supraventricular arrythmias and rarely syncope
- Increased heart rates are disadvantageous as overall diastolic left ventricular filling times will decrease, resulting in higher pulmonary venous pressures
- Rate control with beta blockers/calcium blockers/digoxin seems counter-intuitive but the treatment of choice for tachycardia related CHF with this disorder

8. Ischemia during medivac

A. Diagnosis
- Differentiate ischemic versus non-ischemic chest pains (chest wall, pleuritic, pericardial, anxiety, aortic dissection)
- Obtain basic labs, oxygen saturation, EKG. Compare EKG to baseline to assess for acute Mi or pericarditis

B. Therapy
- Administer 100% O2, nitrates (IV/SL), chewed aspirin, morphine IV as

first line therapy.

- If tachycardic, consider beta blockers if no contraindications (CHF, high degree AV block, hypotension)
- If patient remains hypoxic, consider low level flight (23000 feet) to optimize inspired FiO2

C. Criteria

- Criteria for acute MI
  ➢ Chest pain and new ST elevations of > 0.1 mV in two contiguous leads *or* <u>new</u> left bundle branch block

- Criteria for thrombolysis
  ➢ Clinical scenario of acute MI as described above, no contraindications for administration (Absolute: active bleeding, aortic dissection, recent hemmorhagic stroke, surgery in past 2 weeks, recent significant head trauma or known intracrania neoplasm)
  ➢ *Even when used appropriately, thrombolysis imparts a 1-1.5% risk of bleeding or intracranial hemmorhage.* ***You must be certain of your diagnosis*** *before administering thrombolysis or you may cause more harm than good.*

D. Indications for emergency landing

- Refractory shock/hypotension
- Suspicion of mechanical complications (VSD, papillary muscle rupture / ischemia with significant mitral regurgitation, myocardial rupture)
- Persistent pain with ST elevations > 1 hour after rTPA administration completed (likely lack of reperfusion)
- *Note that emergency landing with immediate transport to a center with cardic catheterization and CVT surgery capabilities will take an average of 2 hours. Thus, if intended destination is within 2 hours, it is preferable to continue to planned destination. Always evaluate total time to definitive care with emergency landing*

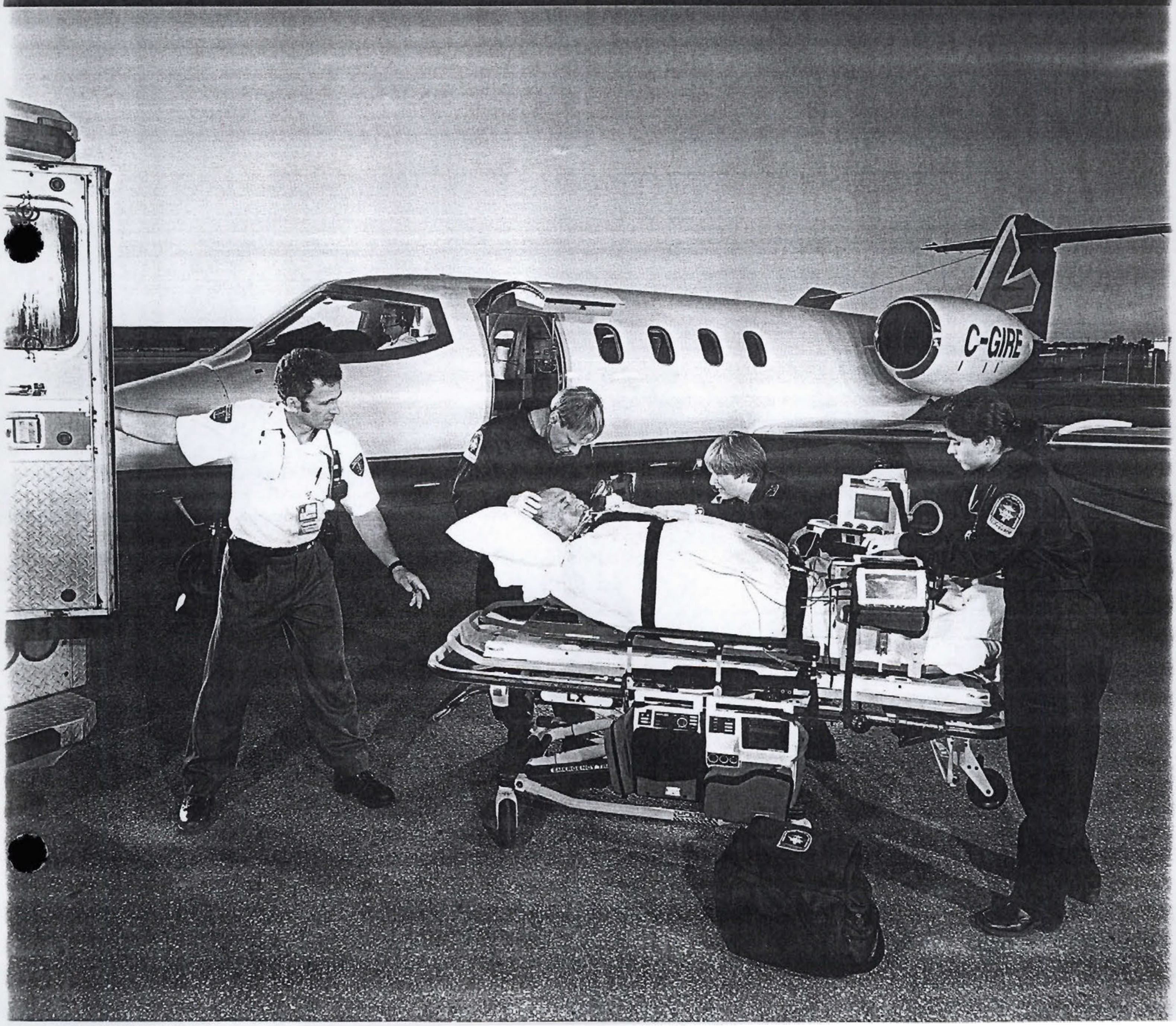
APPENDIX 5

Skyservice Lifeguard Brochures

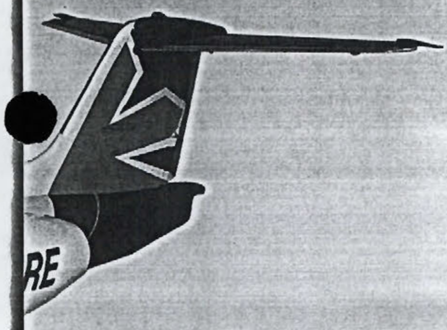
Skyservice

INTERNATIONAL AIR AMBULANCE SERVICES

Skyservice Lifeguard



Skyservice Lifeguard



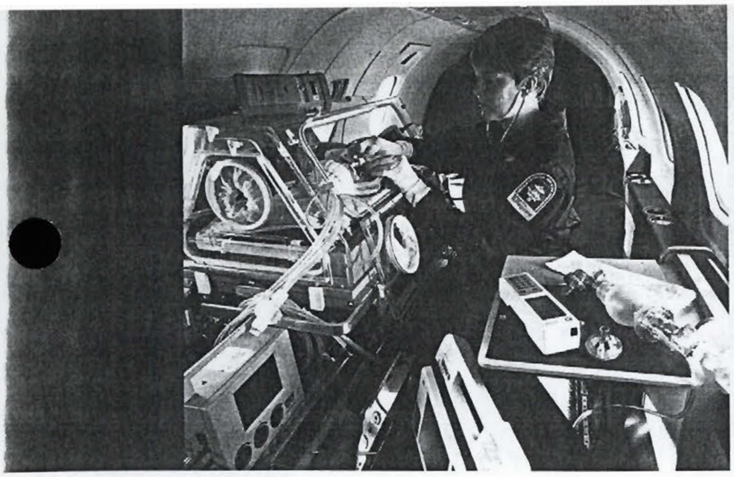
Since its inception in 1989, Skyservice Lifeguard has become the carrier of choice for many of the world's leading travel health insurance companies and an increasing number of private individuals in need of air medical transport.

The Skyservice Lifeguard fleet of mobile intensive care jets stands ready to respond on a moment's notice. Each aircraft is fully-equipped and thoroughly-staffed, ready to retrieve and transport ill or injured patients anywhere in the world.

Skyservice Lifeguard has a rich history in the field of air medical transport, including developing specialized teams and equipment for the Arctic, the Far East and Africa; implementing flight physician training and assessment programs; and flying air medical missions for government organizations, corporations and individuals.

Because of Canada's wide international relations, Skyservice Lifeguard has rapid access to countries that may be difficult for others to enter.

SKYSERVICE'S EXPERTLY TRAINED STAFF GIVES PATIENTS THE HIGHEST POSSIBLE LEVEL OF CARE WHILE IN THE AIR



STATE-OF-THE-ART EQUIPMENT
ALLOWS US TO DEAL WITH CRITICAL
SITUATIONS SUCH AS NEONATAL CARE

Our Services

Whether you need to repatriate a patient aboard one of our mobile intensive-care-configured Learjet aircraft or aboard a commercial airliner, Skyservice Lifeguard offers you:

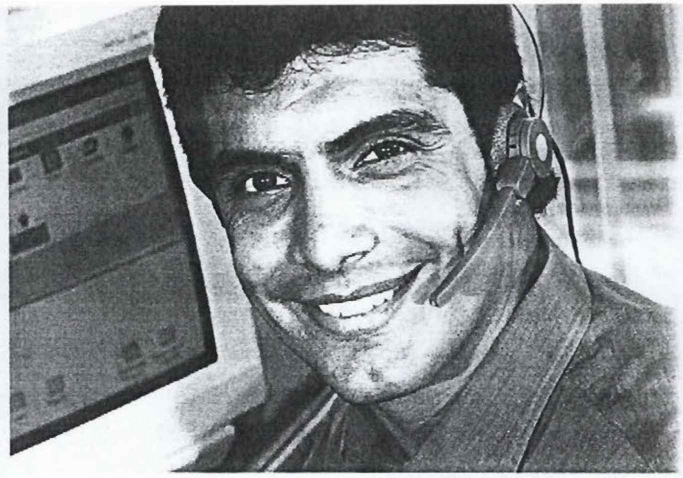
- Fully licensed and experienced personnel with adult, pediatric, and critical care experience, as well as physician-supervised aviation physiology training;
- State-of-the-art medical equipment and supplies;
- Strong medical infrastructure under the aegis of the McGill University Health Centre;
- Preflight assessments, upon request, for all potential repatriations.

Patient Transfers

Skyservice Lifeguard has a reputation for exceptional service in the following specialties:

- Cardiovascular/Cardio Respiratory
- General Medicine
- High Risk Obstetrical
- Pediatrics
- Multiple Trauma including Burns
- General Surgery
- Neurosurgery/Neurology
- Neonatal
- Orthopedics

OUR MULTILINGUAL FLIGHT CO-ORDINATORS ARE AVAILABLE 24 HOURS A DAY, 7 DAYS A WEEK.



Specialized Transfers

With minimal notification, Skyservice Lifeguard provides for the safe transport of patients with hazardous substance exposure, barotrauma, highly communicable diseases, and other specialized transports including patients with intra-aortic balloon pumps. The aircraft are also available for rapid response, organ retrieval flights.

How to Request Services

Skyservice Lifeguard air ambulance service is available 24 hours a day, 7 days a week. Simply call our International Dispatch Centre and speak with one of our multilingual Flight Co-ordinators.

Our staff will make all necessary arrangements for medical personnel and flight requirements. They will advise you of the estimated arrival time of the air ambulance and monitor the flight progress until the patient has been transferred to the receiving health care facility.

Please have the following information available when you contact Skyservice Lifeguard:

- Caller's name and phone number
- Patient name and diagnosis
- Originating hospital
- Name of attending physician
- Preferred time of transfer
- Ambulances or other special arrangements required at the originating and destination hospitals
- Any request for family member to accompany the patient to or from the hospital
- Payment arrangements

Skyservice is a dynamic aviation services enterprise which includes business aviation services, air ambulance and commercial airline operations.

People and values – inseparable assets – drive our dedication to Quality.

Safety, Respect, Commitment and Efficiency are the core values that guide Skyservice people every day and help build the reputation of Skyservice as a leader in aviation services.

Base Locations

Montreal, Quebec, Canada
Toronto, Ontario, Canada

Telephone:	1-800-463-3482 (North America)
	1-514-497-7000 (world wide)
Facsimile:	1-514-636-0096
Email:	lifeguard@skyservice.com
Web:	www.skyservice.com

Skyservice

Skyservice

Skyservice Lifeguard World Wide Air Ambulance Services
Montréal • Toronto • Casablanca
Fort Lauderdale • Lomé • Paris

FOREWORD

Background

Skyservice, in association with the Montreal General Hospital, has developed Skyservice Lifeguard, an air ambulance service with a mandate to provide a full range of aeromedical services including:

- Fast, reliable air ambulance intensive care service worldwide
- Highly trained North American medical personnel
- The most modern support equipment available in the industry
- Aeromedical ground support services
- Complete medical and technical services for airline evacuations

Skyservice is a licensed international air carrier. Operating Canada's premiere passenger charter airline and corporate jet aircraft with extensive air ambulance, aircraft management, aircraft maintenance, as well as advanced avionics installations.

The Montreal General Hospital is a 650 bed tertiary care hospital specializing in all areas of medicine. It is also recognized as a Level 1 trauma center and is one of McGill University's main teaching hospitals.

Our Skyservice Lifeguard division is Canada's leading provider of critical care aeromedical services. The company also offers support services to various airlines including advanced sterilization procedures, drug and inventory supplies, medical equipment and personnel. A proven leader in the aeromedical field.

As Skyservice Lifeguard's expansion continues. Two new full service locations are now operational. Toronto, Ontario and Casablanca, Morocco. Medical staff has been provided and trained in accordance with McGill University's training program in aeromedecine. Client service centers are functional in Paris, France as well as Fort Lauderdale, Florida and Lomé, Togo. Their objective is to serve the needs of our clients in those travel areas.

QUALIFICATIONS/STANDARDS

Hospital Quality Control

Our medical director is also the Director of Emergency Services of the Montreal General Hospital. He or his delegates have the final responsibility for all medical decisions.

Medical Personnel

Patients are accompanied by professionals specifically trained in aeronautical medicine. All medical personnel are also fully accredited in advanced life support and advance trauma procedures.

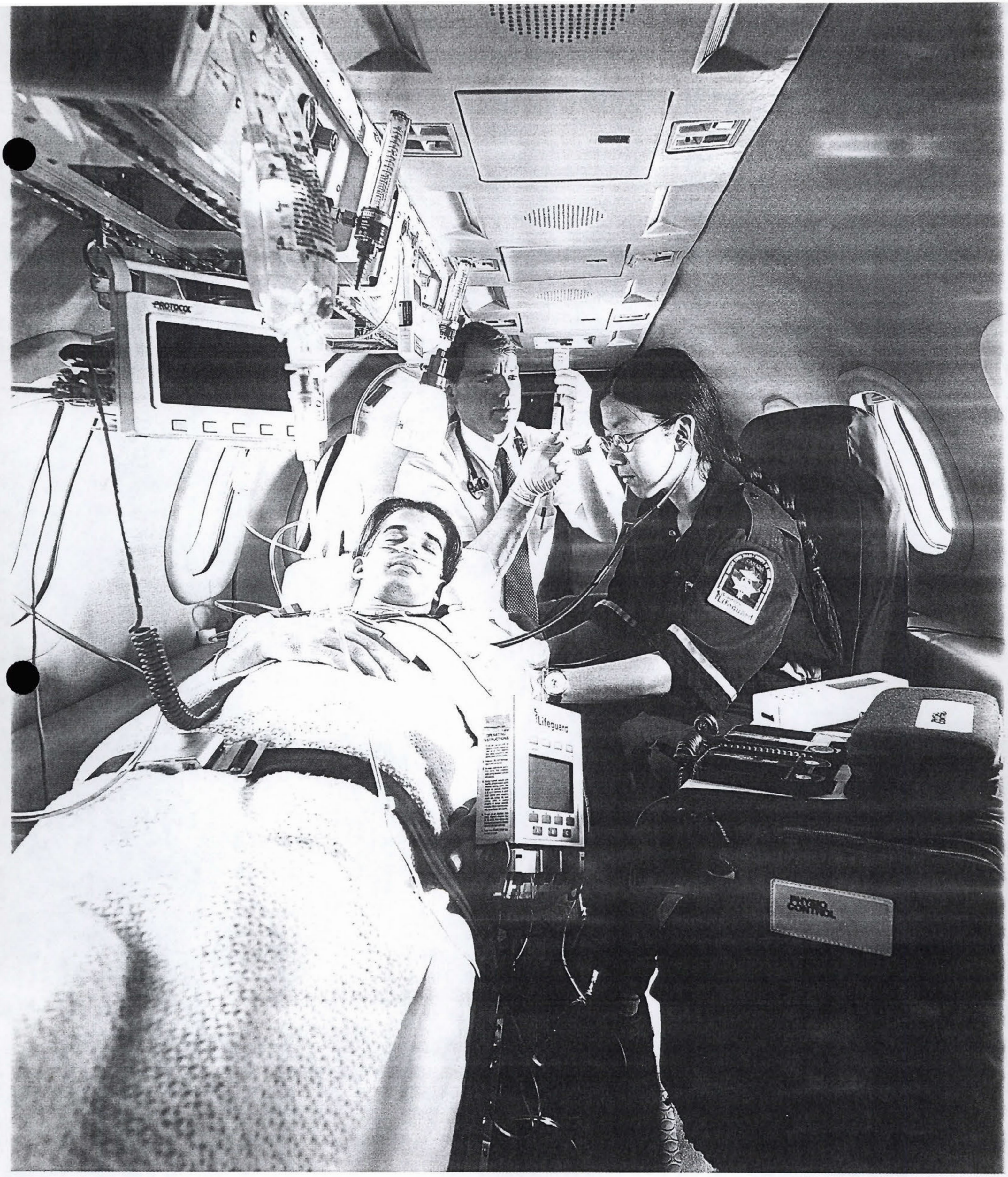
All of our technical medical personnel are fully licensed. Any transfers from a U.S. hospital are carried out under the jurisdiction of the delegated acts which can be carried out by the flight medical team.

Our physicians, paramedics and flight nurses have received specialized training particular to the aviation environment including: safety precautions and emergency procedures, aircraft familiarization and crew coordination, and all are fully conversant with the medical factors particular to the aviation field.

Skyservice Lifeguard conforms to the Air Medical National Standard Curriculum which has been developed by the U.S. Department of Transportation and the National Highway Traffic Safety Administration (NHTSA).

These standards were developed for the training of aeromedical crew members (Paramedics, Nurses and Physicians) and augment the existing educational curriculum regarding emergency care.

Skyservice Lifeguard also adheres to the Air Ambulance Guidelines established by the Emergency Health Services of the Government of Quebec, is a provider member of the Association of Air Medical Services (AAMS). Formal accreditation of compliance to CAAMS (Commission on Accreditation of Air Medical services) standards is pending. Skyservice Lifeguard is also a member of the International Society for Travel Medicine.



Inside view of one of our state of the art Lear 35A intensive care air ambulances

Foreword
Standards
Qualifications
PATIENTS
Medical equipment
Aircraft information
Safety
Reservations
Airline evacuation
Mass casualty services
Areas of operation

PATIENTS

Patients must be cleared by Skyservice Lifeguard medical personnel for air medical evacuation. Flights may be arranged for many types of pathology including the transfer of:

- ➢ Burn patients
- ➢ Cardiac patients
- ➢ Obstetric patients
- ➢ Orthopedic patients
- ➢ Pediatric – neonatal
- ➢ Pulmonary patients
- ➢ Hazardous substance exposure
- ➢ Trauma victims
- ➢ Organ harvesting transport team
- ➢ Hyperbaric-barautrauma cases

Restrictions

In the case of patients with a communicable disease, suitable precautions must be arranged in advance for the safety of crew members and attending staff. While this does not restrict the patient's transfer, special procedures will be put into effect. We will consult with one of our infectious disease specialist prior to flight in order to minimize exposure risks. There are also certain medical situations, such as barotrauma, which may require pre-arranging the use of specialized equipment. For more information please contact Skyservice Lifeguard.

Advanced Life Support

All air ambulances are fixed wing turbine aircraft configured in an Advanced Life Support capacity and as such, are flying intensive care units with full pharmaceutical provisions.

Please see the Medical Equipment section for a complete list of equipment carried on board all flights.

Foreword
Standards
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MEDICAL EQUIPMENT
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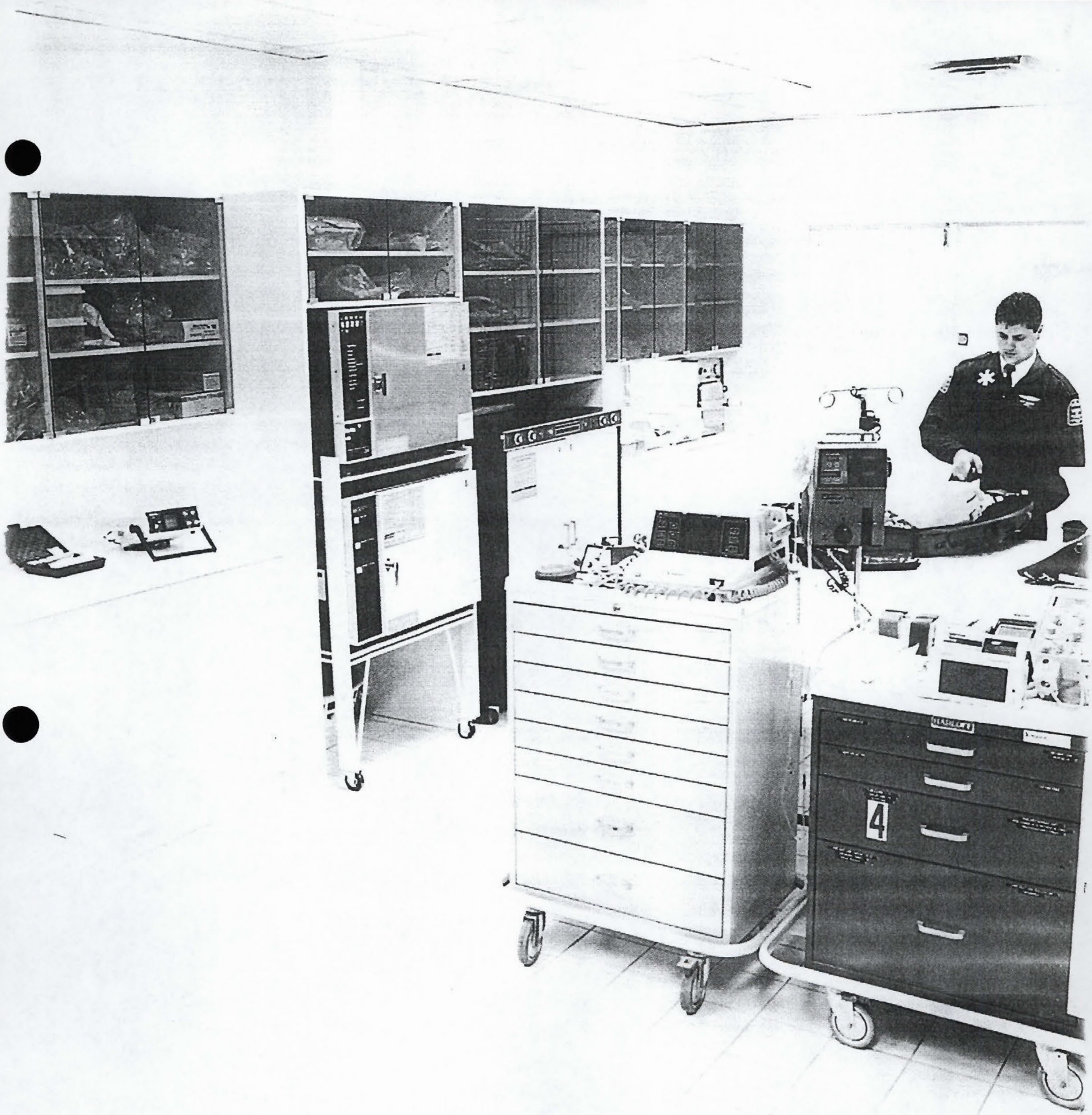
MEDICAL EQUIPMENT

CARDIAC MONITORING	12 lead cardiac monitor with Synchronous and asynchronous defibrilator-cardioverter Code summary software Remote defibrilation/pacing
HEMODYNAMIC MONITORING	Invasive blood pressure (CVP, Arterial, LAD, PA) Electronic sphygmomanometer Cardiac output computer Doppler device
ARRHYTHMIA CONTROL	Pharmacologic agents External transvenous atrial/ventricular pacing External transcutaneous pacing
OXYGEN THERAPY	Liquid oxygen converter Humidified or nebulized O_2 administration Metered venturi oxygen supplementation Precision oxygen blender (air/oxygen) Nitronox administration unit
VENTILATION MONITORING	Positive end expiratory pressures – CPAP Rate (IT, ET, I:E ratio) Tidal volume (inspiratory, expiratory, compliance) Breathing pressures (PIP, MAP, Trending)
GAS EXCHANGE MONITORING	Pulse oximetry, plethismography End tidal CO_2 monitors Streamline CO_2 monitors
INTUBATION THERAPY	Endotracheal intubation kit with ET CO_2 sensors Chenoeth intubator with fiber optic illuminator
MANUAL VENTILATION	BVM with and without PEEP Pediatric – neonatal BVM with and without PEEP
GASTRO INTESTINAL	Variable flow suction Enteral feeding pump
BLOOD GAS ANALYSIS	i-STAT blood gas analyser pH, PCO_2, PO_2, Glucose, HB, HT, SaO_2, K, P, HCO_3, Na, Cl



Montreal, Canada
Sterilization room

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MEDICAL EQUIPMENT

MECHANICAL VENTILATION	Pressure support – electronic ventilator Volumetric ventilators Pressure plateau time cycled ventilators Multi function ventilation monitors CPAP – peep (0 to 20 cm. H_2O) PEEP Expired gas biological filter Isolate loop suction circuit
ORTHOPEDIC/ TRAUMA	Cervical spine and torso immobilization Long bone fracture stability maintenance Vacuum mattress immobilizer Fluidized stretcher Orthopedic/traction splints
OBSTETRIC GYNACOLOGY	Obstetrical pack Delivery room kits Ultrasound Fetal heart monitor Newborn ressucitation
BARO TRAUMA	Gamow portable low pressure hyperbaric chamber available with a decompression computer, oxygen analyser and independent oxygen supply
IV FLUID ADMINISTRATION	IV fluid warmers Standard varieties of IV fluid – Plasma volume expanders Pneumatic and mechanical pressure infusers Multi channel infusion pumps Piggyback pump
ISOLATION	Infectious transport isolation tent HEPA filtered hood for the crew Hazardous substance decontamination material
PHARMACY	Full ALS pharmacy Thrombolytic agents Pediatric ALS Pharmacy Surfactants


Lifeguard

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MEDICAL EQUIPMENT
PEDIATRIC/NEONATAL MEDICAL EQUIPMENT

PEDIATRIC/ NEONATAL ISOLETTE

A double wall isolette with electronic temperature control and high output humidification is custom designed for our harsh climate. The isolette is mounted on a custom made Lifeport Aerosled cargo stretcher, this provides the assurance of a hard mount isolette fixed to the aircraft during flights. On the ground a special stretcher system ensures safe ground transfers.

VENTILATOR

Skyservice Lifeguard uses propriatary ventilator technology capable of providing a wide spectrum of respiratory wave compliance. Our unique ultra low volume pneumotach analyser coupled with advanced plethismography and respiratory analysis enable us to reproduce the exact inspiratory demand and adjust all ventilatory levels in order to provide the optimum pressure support from the micro-premature infant to the older child.

ULTRASOUND AND DOPPLER

Skyservice Lifeguard carries a number of ultrasound probes and a doppler device to aid in diagnostic and invasive procedures. Our 10° 16 cm monochrome display is the most advanced miniature ultrasound available today.

VITAL SIGN MONITORING

We are equipped to electronically monitor and record invasive and non-invasive blood pressure, umbilical arterial line pressure, O_2 saturation, end-tidal CO_2, as well as surface/body temperature. Our cardiac monitors are equipped with remote defibrillation and multi-sequential pacing ability.

SPECIALIZED TRANSFERS

We have access to highly specialized equipment enabling us to do specialized transfers including intra-aortic balloon pump and extra corporal membrane oxygenation (ECMO) candidates. High frequency jet-ventilation transfers require longer lead times for evacuation.


bmd

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AIRCRAFT INFORMATION

Air Ambulance Intensive Care Units

Skyservice Lifeguard aircraft have been specifically modified to safely transport patients and the necessary medical staff to medical facilities virtually anywhere in the world. Skyservice Lifeguard principaly uses two types of aircraft:

- Lear 35A Jets
- Cessna Citation Jets

On request other aircraft in the fleet can be modified for a specific requirement

The aircraft selection for a specific trip will be decided by our customer service personnel and the customer's representatives based on suitability, availability, and cost.

Skyservice Lifeguard aircraft are equipped with a medical interior designed and installed by Skyservice Lifeguard using Lifeport stretcher systems. They feature loading ramps and aero-sled stretcher systems in order to ensure smooth entry and exit of patients. All aircraft are pressurized and carry supplemental oxygen independent of medical supplies.

Passenger Capacity

All aircraft are equipped to transport up to two patients at a time. Every effort will be made to accommodate family members whenever possible. However, the requirement of additional medical personnel or equipment may preclude this possibility. The final decision will rest with the medical team and the captain of the flight.

Airline Medical Evacuations

In the event that the patient can be accommodated by commercial airlines, Skyservice Lifeguard will make all necessary arrangements and provide medical personnel and equipment to ensure a safe and efficient transfer.

Lear 35

The Learjet travels at 520 mph and cruises at 35,000 – 45,000 feet. It has a range of approximately 2,350 miles (4.5 hours). The cabin is pressurized to an altitude of 8,000 feet at 45,000 feet.

Cessna Citation

The Citation is a twin engine jet which cruises at 350 mph at altitudes of between 30,000 and 35,000 feet, with a range of approximately 1,300 miles (3.5 hours).

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SAFETY

Skyservice Lifeguard air ambulance service is available 24 hours a day, 365 days a year. Our aircraft are equipped with state of the art navigation equipment. This permits precise navigation to remote areas and enables us to operate in almost all weather conditions.

Backup Equipment

Skyservice Lifeguard aircraft are modified with dual independent electrical systems and are dispatched with a minimum of eight hours emergency power backup for the medical devices.

Survival Equipment

When operating in sparsely inhabited areas of the world, Skyservice Lifeguard medevac aircraft carry survival equipment including emergency exposure suits and extreme environment shelters.

Safety Audits

Operations are constantly reviewed to ensure safety for patients and crew. Formal safety audits are carried out twice a year.

Insurance

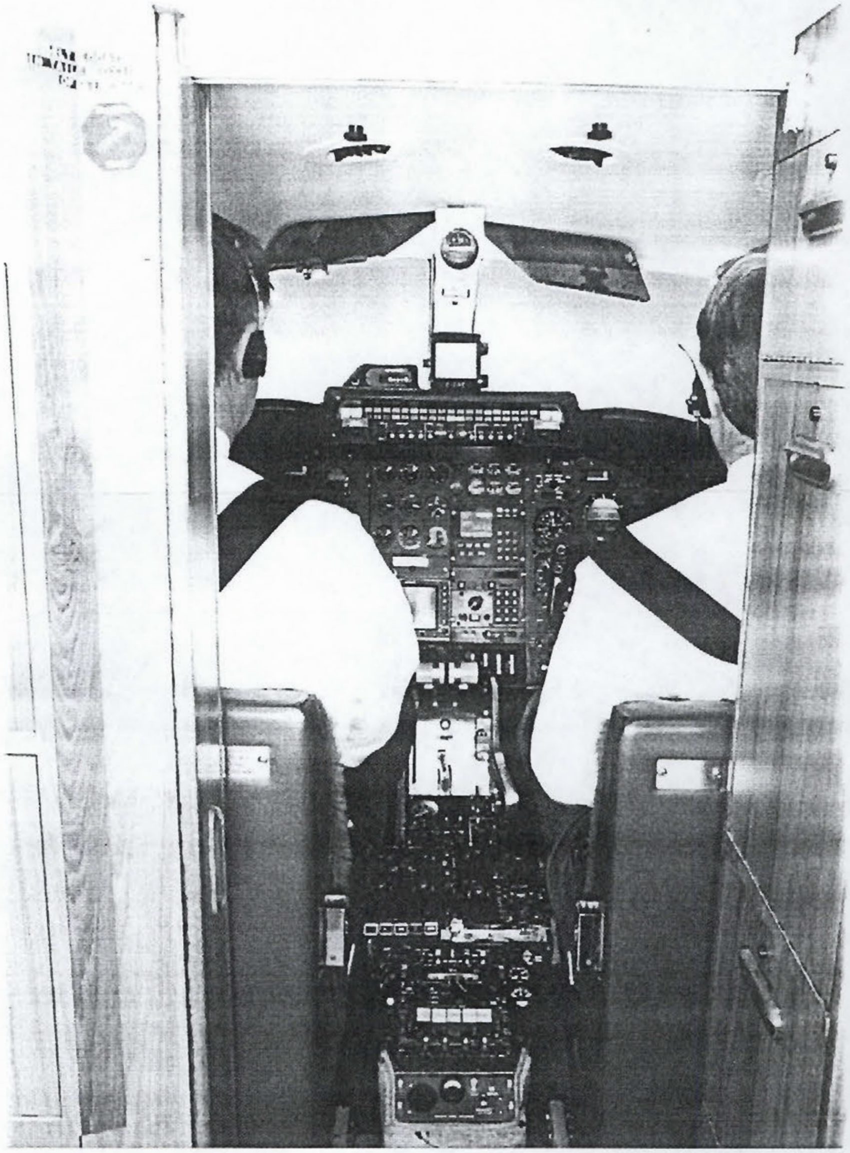
Skyservice Lifeguard is fully insured for the transportation of patients and attendants at all times. Additional and separate policies are in place for the U.S. Further information may be obtained upon request.

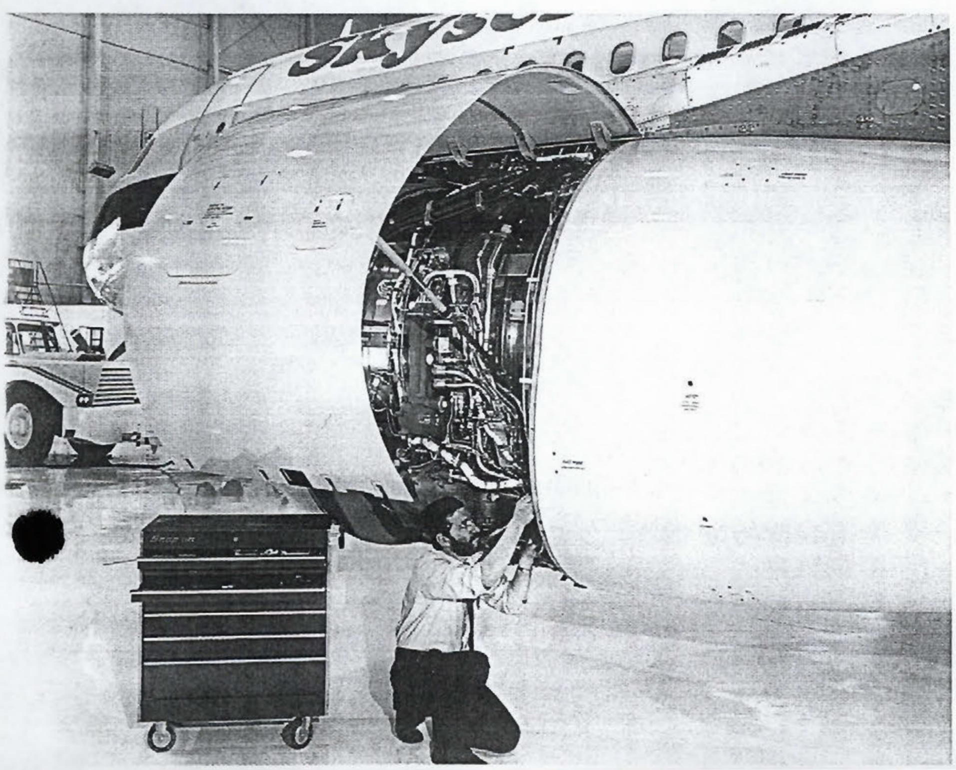
Toronto medical crew completing
Pre flight medical equipment checks

Flight Crews

Aircraft are operated by two fully qualified pilots on all flights. All captains are type rated on the aircraft and hold Airline Transport Ratings with Class 1 instruments ratings and have a minimum of 4,000 hours experience.

Training is done through Simuflite and Flight Safety, two well respected training facilities. Pilots are routinely scheduled for recurrent simulator training and are examined every six months by either Ministry of Transport Inspectors or Company Check Pilots.





Maintenance

Maintenance is performed by Skyservice at its bases in Toronto and Montreal. Staff are available 24 hours a day with all of the support services necessary to ensure the serviceability of the aircraft at all times.

Maintenance checks are performed after every flight on all aircraft.

RESERVATIONS

Reservations

Air ambulance service is available 24 hours a day. 365 days a year by telephoning Skyservice Lifeguard at:

☎ In North America	(800) 463-3482 – (888) 463-3482
☎ Fax	(514) 636-0096
E-Mail	lifeguard@skysrvc.com

Although flight crews are ready to depart within 90 minutes of the initial request, transportation ideally should be arranged in advance to coordinate the efficient transfer of the patient.

Required Information

Users of the service should have the following information available when they contact Skyservice Lifeguard:

- ☐ Caller's name and contact phone number
- ☐ Patient name and diagnosis
- ☐ Originating hospital
- ☐ Name of the attending physician
- ☐ Preferred time of transfer
- ☐ Ambulances or other special arrangements required at the originating and destination hospitals
- ☐ Any request for family member to accompany the patient to or from the hospital
- ☐ Payment arrangements

Skyservice Lifeguard dispatchers will then make all necessary arrangements for medical personnel and confirm the flight. They will advise you of the estimated arrival time of the air ambulance and monitor the flight progress until the patient has been transferred to the receiving hospital.

Administrative Calls

Staff members are available for administrative calls between 8 am and 6 pm Monday to Friday at (514) 636-3300.

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AIRLINE EVACUATION AND MASS CASUALTY SERVICES

Airline Evacuations

Skyservice Lifeguard is accredited on major Canadian Commercial airlines. We provide oxygen, stretchers and advanced life support equipment for airline transfers.

Skyservice Lifeguard will assist airline companies and insurance providers with bedside to bedside airline evacuation services when an air ambulance is not required.

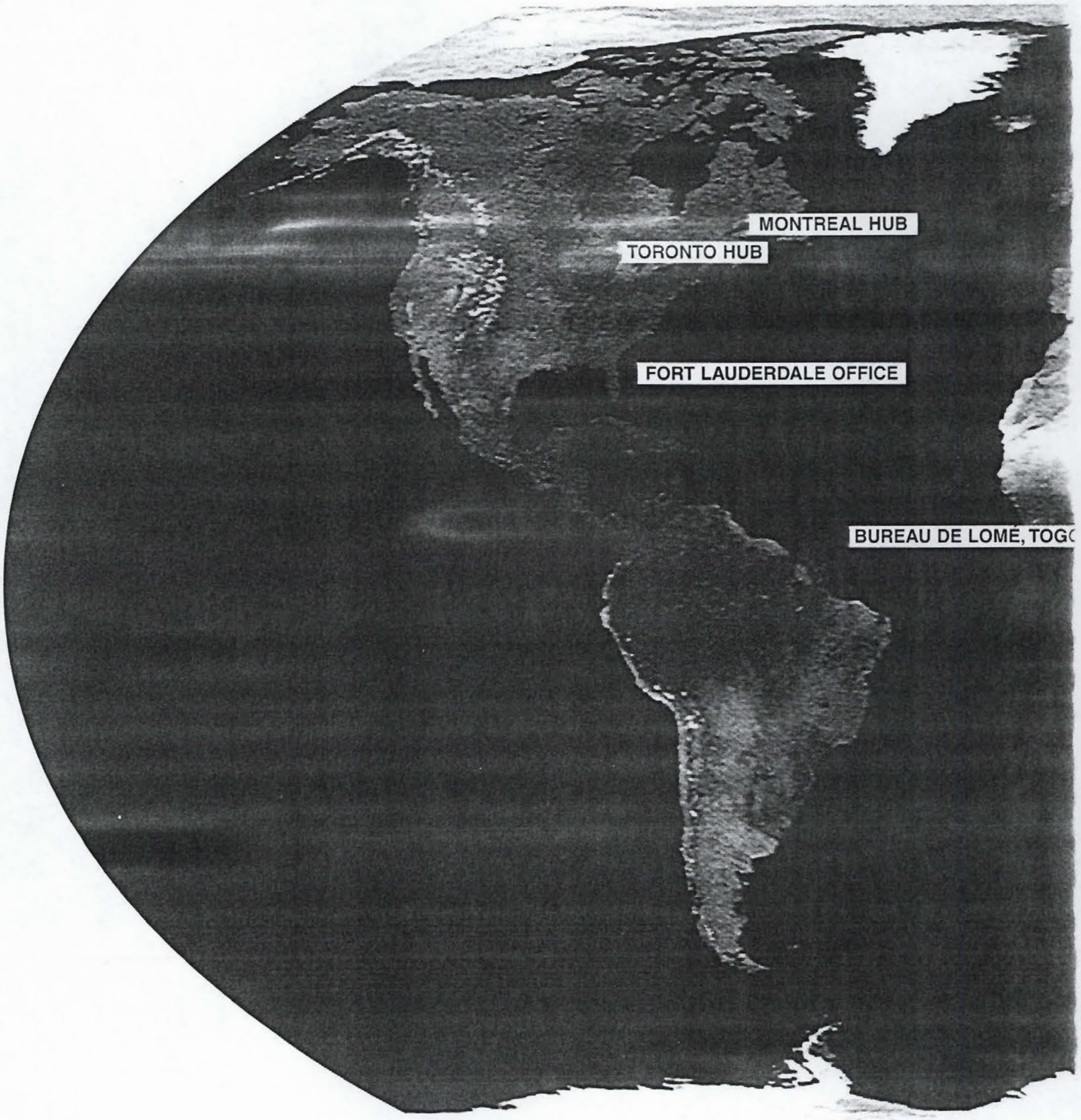
Mass Casualty Services

Skyservice Lifeguard has a rich heritage in Mass casualty and special situation mass evacuations. We have co-ordinated events as varied as the Pope Jean-Paul II visit to Quebec, (where our field units treated more than 730 patients), to train derailments and civil conflicts (such as the Oka incident). Anywhere that you may need us in case of mass casualty, we can bring our 20 bed field hospital as a transition point before airlifting your patients in our fully equipped air ambulances. Should your local resources be over-extended, our MCI team from the Montreal General Hospital will join us in providing quality health care under your directives.

Typically these services do require a few hours of preparation before being airborne. Our first response team will be in the air in less than an hour from your call to help evaluate the level of services required. We can work with affiliate providers in larger evacuation situations. We can also transport less serious patients in a sitting position in our Gulfstream 1 aircraft. It is important to have as much advanced information as possible on your evacuation requirements in order that we dispatch our aircraft in the shortest time possible.

AREAS OF OPERATION

Skyservice Lifeguard is a truly global air ambulance service. Normal areas of operation include North and South America, Europe, Africa and the Carribean.



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H9P 1A2

Skyservice Lifeguard
5501 Electra Road
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L5P 1B1

Field Offices:
Paris, France • Lomé, Togo

Skyservice Lifeguard
Aero Multi Services Atlas
6, rue El Hajeb
.L. Casablanca, Morocco

Skyservice Lifeguard Inc.
1100 Lee Wagener Blvd.
Suite 314
Fort Lauderdale, Florida 33315

One of our Lear 35's in flight

Skyservice

Skyservice Lifeguard World Wide Air Ambulance Services
Montréal • Toronto • Casablanca
Fort Lauderdale • Lomé • Paris