Categorization of strategic points of flight physiology for aeromedical transport

RESUMO | Objetivo: Categorizar os pontos estratégicos da fisiologia de voo que possam interferir no transporte aeromédico. Método: Trata-se de um estudo de revisão integrativa de literatura, realizada com base no modelo PRISMA - Preferred Reporting Items for Systematic Reviews and Meta-Analyses. A busca dos artigos foi realizada nos meses de agosto e setembro de 2021. Resultado: Foram utilizados 10 trabalhos, elencadas seis categorias: (i) Altitude; (ii) Áreas comuns que precisam de atenção; (iii) Forças de Aceleração; (iv) Hipóxia, (v) Preparação para o voo do paciente; (vi) Umidade, Temperatura e Gravidade. Conclusão: O transporte em aeronaves de asa fixa necessita de um conhecimento de fisiologia de voo, potenciais alterações na altitude, recomendações específicas, equipe de saúde e tripulação capacitadas para reconhecer e intervir. Assim como, possuam práticas avançadas, compartilhem as informações, maximizem os processos de segurança e qualidade no ambiente hipobárico.
Descritores: Enfermeiros; Fisiologia; Resgate Aéreo; Capacitação; Gestão do Conhecimento.

ABSTRACT | Objective: To categorize the strategic points of flight physiology that may interfere with aeromedical transport. Method: This is an integrative literature review study, based on the PRISMA model - Preferred Reporting Items for Systematic Reviews and Meta-Analyses. The search for articles was carried out in August and September 2021. Result: 10 works were used, listed in six categories: (i) Altitude; (ii) Common areas that need attention; (iii) Acceleration Forces; (iv) Hypoxia, (v) Preparation for the patient's flight; (vi) Humidity, Temperature and Gravity. Conclusion: Transportation in fixed-wing aircraft requires knowledge of flight physiology, potential changes in altitude, specific recommendations, health care team and crew trained to recognize and intervene. As well as having advanced practices, share information, maximize safety and quality processes in the hypobaric environment.
Descriptors: Nurses; Physiology; Air Rescue; Training; Knowledge management.

RESUMEN | Objetivo: Categorizar los puntos estratégicos de la fisiología del vuelo que pueden interferir con el transporte aeromédico. Método: Este es un estudio de revisión de literatura integradora, basado en el modelo PRISMA - Ítems de reporte preferidos para revisiones sistemáticas y metaanálisis. La búsqueda de artículos se realizó en los meses de agosto y septiembre de 2021. Resultado: se utilizaron 10 obras, clasificadas en seis categorías: (i) Altitud; (ii) Áreas comunes que necesitan atención; (iii) Fuerzas de Aceleración; (iv) Hipoxia, (v) Preparación para el vuelo del paciente; (vi) Humedad, temperatura y gravedad. Conclusión: El transporte en aeronaves requiere conocimientos de fisiología de vuelo, posibles cambios de altitud, recomendaciones específicas, equipo de atención médica y tripulación capacitados para reconocer e intervenir. Además de contar con prácticas avanzadas, compartir información, maximizar los procesos de seguridad y calidad en el ambiente hipobárico
Descriptores: Enfermeras; Fisiología; Rescate aéreo; Capacitación; Conocimiento administrativo.

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INTRODUCTION

The origins of air medical transport date back to the late 19th century, when hot air balloons were used to evacuate the wounded from the battlefield 1 and the first report of successful air transport took place at the Siege of Paris by Germans in 1870 using hot air balloons, 2 but this method of transport was not successful until ninety years later. The list of balloons and aerial devices that Santos Dumont designed or built has gaps, inconsistencies and implausible data that cannot be explained. 3

The first half of the 20th century saw a rapid development of air medical transport capabilities. Keeping with advances in military science, the US Air Force commanded a team approach to critical care airlift in 1994 at the 59th Medical Wing of Lackland Air Force Base, calling it the 'critical care airlift team'. 4

In this sense, civil air medical transport is increasingly used. It is worth learning from previous experiences, both military and civilian, in order to improve processes, care for critical patients and results, safety and quality.

To this end, the discussion with a group of researchers specializing in air transport of critically ill patients emerged from everyday practice. This was followed by the guiding question: "what are the topics to be studied about flight physiology prior to aeromedical care?" Thus, the aim of this study was to categorize the strategic points of flight physiology that may interfere with aeromedical transport.

METHOD

This is an integrative literature review study, based on the PRISMA model - Preferred Reporting Items for Systematic Reviews and Meta-Analyses. 5

The search for articles was carried out in August and September 2021, in the online portals: Capes Journals, Virtual Health Library (BVS) and Scientific Electronic Library Online (SCIELO). The following keywords were used: “gestão do conhecimento”, “transporte de pacientes”, “fisiologia de voo” and their respective in English: “knowledge management”, “patient transport”, “flight physiology”. For the selection of articles, the following criteria were used: studies published between 2006 and 2021 that addressed the training process of professionals in the aeromedical service. Works not found in full, publications prior to 2006 and in languages other than English and Portuguese were excluded.

The selection started by identifying the publications based on their titles, followed by reading the abstracts and including those that had all the criteria after reading in full, as described in Figure 1.

A total of 307 publications were located, five works were duplicated when performing the analysis of the results. Next, a selection was made of the works that addressed the subject by reading the title and abstract, reaching 22 articles, when reading in full, 12 were excluded and 10 works were included.

Keeping with advances in military science, the US Air Force commanded a team approach to critical care airlift in 1994 at the 59th Medical Wing of Lackland Air Force Base, calling it the 'critical care airlift team'

RESULTS

The 10 selected and described studies were published in international journals, as shown in Table 1.

DISCUSSION

Aeromedical transport systems may include rotary-wing (helicopter) or fixed-wing (airplane) aircraft. In addition, the health crew may be responsible for ground transportation (ambulance) to and from the hospital, airport or helipad. To do this, the team must be familiar with safety and be able to work with the different types of ambulances in your system. Analogous to emergency systems (Emergency Medical Services EMS), the aeromedical crew operates, using protocols and standing orders, indirectly. In Brazil, it can be any combination of the following professionals: doctor/a; nurse and perfusionist. 2

In this way, knowledge of aerospace medicine and physics is vital information for teams in air medical transport. The keys to a successful aeromedical evacuation are planning, responding to any deterioration in the condition that led to urgent transportation, and conditions induced by the aerospace environment. 11 It is noteworthy that the categorization of the six strategic points is related to flight physiology and, consequently, aligned with the pathophysiology of the critically ill patient in the air environment.

Altitude

As far as aerospace physiology is concerned, there are different physiological zones of the atmosphere that become relevant. The efficient zone is defined as an altitude of 10.000 feet (3.000m) above sea level. In this zone, oxygen levels are typically adequate to maintain baseline physiology without a strong need for supplemental oxygen or equipment. However, upon reaching the deficient zone of the atmosphere, 10.000 feet to 50.000 feet above sea level, there will be a decrease in barometric pressure as well as a decrease in oxygen partial pressure. 8

In the handicapped zone, most flights operate and it is also where physiological events occur during aeromedical transport. For a better understanding of the events that occur during flights, attention should be paid to the Boyle and Dalton laws. 8

Common areas that need attention

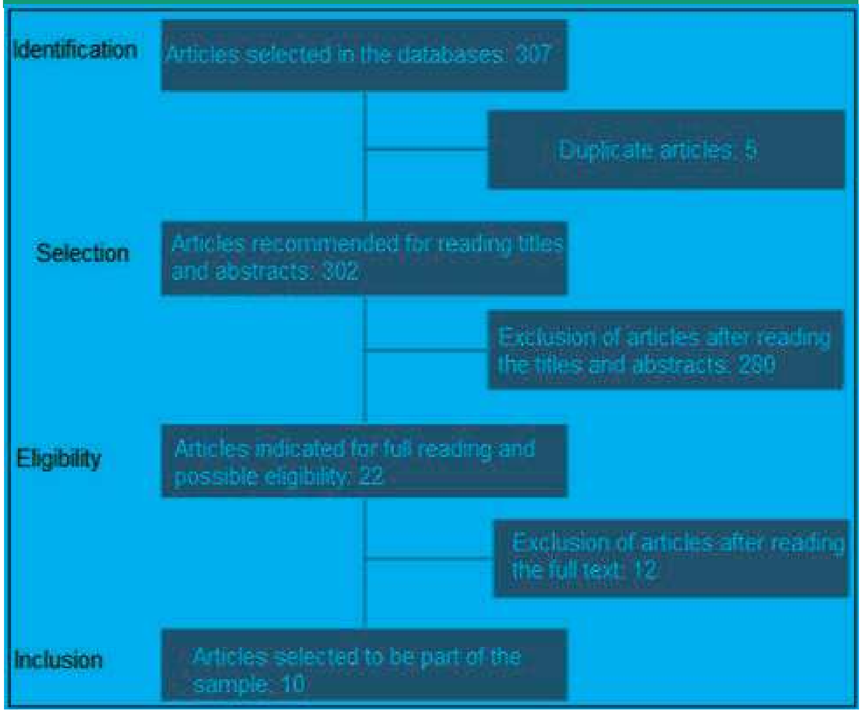
Australian researchers claim that direct communication between air medical transport physicians and destination hospital physicians can improve the accuracy of clinical information for the patient's well-being. 10

During the dialogue between the teams, the minimum information must be relayed. There are standardized tools that ensure better communication between teams, that is, the use of checklists and the retransmission of information in a structured way. 8 Still, the recommended tool to standardize communication related to patient information is iSoBAR (identify-situation-observations-background-agreed plan-read back), that is, identify the situation and history, evaluate and recommend. In other words, good communication always favors patient care and improves results. 9,10

Acceleration Forces

The analysis of gravitational forces experienced in acceleration and deceleration can impact changes in the physiological processes of critical patients

Figure 1. Study selection flowchart, according to pre-established inclusion and exclusion criteria.



Fonte: Elaborado pelos autores, 2021.

Table 1. Titles of studies, categories covered and years that were published.

Títulos	Anos	Categorias
Preparation of the critical patient for aeromedical transport.6	2014	Preparation for the patient's flight Common areas that need attention Hypoxia
Recommendations for the intra-hospital transport of critically ill patients.7	2010	Preparation for the patient's flight
Principles of air transport physiology for JMATT clinicians.8	2012	Altitude
Aero-medical considerations in casualty air evacuation (CASAEVAC).9	2010	Preparation for the patient's flight
iSoBAR – a concept and handover checklist: The national clinical handover initiative.2,9	2009	Common areas that need attention
Critical Considerations for Fixed-Wing Air Medical Transports.2	2019	Hypoxia Humidity, Temperature and Gravity Forças de Aceleração

When place and time matter: how to conduct safe inter-hospital transfer of patients.10	2014	Humidity, Temperature and Gravity Acceleration Forces Preparation for the patient's flight Common areas that need attention
Clinical decision support systems come of age.11	2007	Hypoxia
Guidance on: guidelines for the transport of the critically ill adult.12	2019	Acceleration Forces

Source: Prepared by the authors, 2021.

Table 2 - Oxygen and temperature changes at altitudes [2]

Altitude (feet)	Pressure atm/t* (mmHg)	PaO2 (mmHg)*	PaO2 (mmHg)**	Oxygen Saturation (%) (%)	Temperature in Celsius
Sea level	760	160	100	98	15
8.000	565	118	69	93	-0.8
10.000	523	110	60	87	-4.8
18.000	379	80	38	72	-20.7
20.000	349	73	34	66	-24.6
35.000	179	38	0	0	-55

Notes: (*) Total atmospheric; (**) Alveolar oxygen partial pressure; (***) Partial pressure of arterial oxygen
Source: Adapted by the authors, 2021

and the effects may be exacerbated. 10 Acceleration can lead to hypertension, dysrhythmias, changes in compartmental fluids, tachycardia, and increased intracranial pressure. 2,10 Also, the effects of noise and vibration in air transport can cause pain, nausea and anxiety and, therefore, must be recognized by health care teams and must be treated appropriately. 1

In-flight hypoxia

In the study of altitude-related physiology, the most common consequence of flight is hypoxia. Dalton's Law helps to explain its mechanism, stating that the total pressure of a gas mixture is equal to the sum of the partial pressure of each gas in the mixture: PT = P1 + P2 + + PN. As the altitude increases, oxygen partial pressure decreases. To combat this effect, modern aircraft fly with pressurized cabins at an altitude of approximately 8.000 feet. 2 Thus, patients with hypoxia or respiratory impairment in the pre-flight phase will likely deteriorate their breathing pattern during the transfer if no efforts are made to optimize your oxygenation. 6

Boyle's law explains that the volume of a gas is inversely proportional to the pressure to which it is subjected", P1/P2 = V1/V2. Based on this law, the pressure decreases with increasing altitude and thus causes the increase in gas volume, which leads to the concept of gas expansion.

Given the above, potential consequences of gas retention/expansion can happen. 11 There are spaces in the various body cavities susceptible to expansion during flight and, consequently, complications. Still, some efforts are needed to equalize the pressures of the respective cavities and the health professional must be prepared to intervene.

Preparation for the patient's flight

It is necessary that, during the preparation of critically ill patients, air-removed, in fixed wing aircraft, there is proper planning and execution is impeccable. Patient preparation must be extended to everyone involved in the processes. Therefore, the holistic approach to transfer provides improved results and optimizes security. The patient transfer processes must be guided by the use of standardized procedures, as they can help to mitigate the associated risks. 7

The critical step in patient transport is the assessment and stabilization of their airways. If you do not have a permanent airway and/or are using mechanical ventilation, the on-board health team must assess, identify and intervene in cases of impairment due to discomfort or respiratory failure. Depending on the severity, ventilatory devices will be instituted and it is necessary that the patient be electively intubated for transport. 10

Airway management should ideally be carried out in the pre-flight phase. Patients using ventilatory prostheses (tubes, laryngeal masks and others) must use efficient fixators (there are several models on the market) that are able to prevent loss of the devices. 6,13

Humidity, Temperature and Gravity

Among the strategic points, there are other physiological considerations that include low humidity, temperature changes and the effects of gravitational forces. Regarding the cabin's low humidity, patients experience dryness of secretions (eyes, nose, mouth, respiratory tract, others), dehydration and increased mucus. 10

Researchers Pritchard et al. (2019) demonstrated that as altitude increases, atmospheric temperature, oxygen partial pressure and humidity decrease. The risk of epistaxis is also increased and for this, the health crew needs to be prepared to manage this complication and provide the best possible care to the patient. 2 By recognizing the hostile environment and the expected effect, assistance will be organized and safe, 10 as shown in Table 1.

In this context, the six categories and their particularities were briefly described. It is hoped that this study has contributed to improving the understanding of flight physiology for transporting critically ill patients, with information sharing and knowledge management. It is known that there are other stressors, particularities of the environment, the need for a trained multidisciplinary team. For this, the air environment with highly specialized teams optimizes safety and quality of assistance. 14

CONCLUSION

Air transport of patients in fixed-wing aircraft requires knowledge of flight physiology, potential changes in altitude, and specific recommendations. For this, the health team and crew must be trained to recognize and intervene, as needed.

Given the above, it is important that health professionals have advanced practices, training, share information among peers, know the flight physiology, maximize safety and quality processes in the hypobaric environment.

Thus, the aim of this study was to categorize the strategic points of flight physiology that may interfere with aeromedical transport. This study suggested new research to fill the gaps in publications.

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