Therapeutics and Clinical Risk Management

Dovepress

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REVIEW

Haemodynamic Changes in Adult Patients Transported in Emergency Medical Helicopters. A Systematic Review

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Objective: Patients transported by Helicopter Emergency Medical Services (HEMS) suffer a series of haemodynamic changes, mainly in terms of blood pressure, heart rate, and oxygen saturation, which worsen at different stages of the flight. The aim of this study was to identify haemodynamic changes in adult patients transported by the Helicopter Emergency Medical Service.

Methods: A systematic review of studies published between January 2013 to April 2023 was conducted following the PRISMA 2020 guidelines criteria in the Pubmed, Scopus and Web of Science electronic databases. Methodological quality was assessed using the critical appraisal tool for non-randomised studies of the Joanna Briggs Institute (JBI). The followed protocol has been registered in the International Prospective Register of Systematic Reviews (PROSPERO) with code CRD4202222355798. Two independent reviewers read and extracted the information of the studies.

Results: Eight studies were included in the review, which showed significant haemodynamic changes during transport by HEMS. All studies recorded readings at three points of the mission: pre-flight, in-flight, and post-flight. The greatest change in physiological variables is visible in oxygen saturation, during the in-flight phase, with a decrease in this value. Blood pressure mainly increased in various phases of the mission, especially in the in-flight phase. Heart rate also changed across the mission phases, mainly in the pre-flight and post-flight phases, increasing and decreasing during the flight.

Conclusion: Patients transported by helicopter undergo haemodynamic changes during the different stages of evacuation (pre-flight, in-flight, and post-flight). However, there is a need for further studies on helicopter transport of patients due to the paucity of publications on this topic.

Keywords: Air rescue, haemodynamics, patient transport, heart rate, oxygen saturation, blood pressure, haemodynamic monitoring

Introduction

Air transport of critical patients by Helicopter Emergency Medical Services (HEMS) is more efficient than by other means of transport in terms of the resolution of urgent and emergency situations, as it allows access to complex geographical locations and also provides a safe transfer in adverse weather conditions in a minimum amount of time. Compared to other medical transports, it even reduces morbimortality during transport, especially in time-dependent pathologies.[1]

The main objective of helicopter transport is the rapid transport of a patient to a hospital that has the necessary resources to optimise care; in this sense, it is vital to ensure fluid communication between the receiving entity, the HEMS,

Received: 8 August 2024
Accepted: 17 October 2024
Published: 23 November 2024

and the Emergency and Urgent Care Coordination Centre to guarantee the availability of human and technological resources for the care of the patient.[2]

HEMS, fly with rules, the Cat A take-off profile is the type of take-off that medical helicopters have to comply with the JARPOPS3 regulations, governing the sanitary flight regulations, being a vertical exit with a small backward deviation from the verticality at take-off. On other continents EC-145, EC-135, Leonardo 109 and Leonardo 139 are the usual models, since it has been seen that the manoeuvrability.[3]

HEMS provides first responders, ie on-site emergency care, in the majority of cases worldwide (81.1%). The most common emergencies involve traumas and cardiovascular conditions. Only 18.9% are inter-hospital transfers.[4] Among the common users of this service, it could include cardiovascular, respiratory and trauma patients.[4,5]

The need for inter-hospital transfer of intensive care patients has been gradually increasing in recent years. When local therapeutic resources for complex treatments are limited, or when specialised patient care is indicated, inter-hospital transfer is recommended to facilitate the most appropriate treatment for the patient. For optimal outcomes, transfers should be performed as early as possible in the disease/injury process, while adhering to a high level of standards of care.[5]

When providing health care during the transport, whether pre-flight, in-flight, or post-flight, it is necessary to bear in mind two factors. On the one hand, the haemodynamic destabilisation derived from the patient's own pathology and, on the other hand, that derived from the air transport itself, which includes climatological factors, temperature variations, changes in atmospheric pressure, noise levels, vibration, and acceleration.[6,7]

These factors are described as physically stressful impulses, thus making the care of air transport pathophysiology unpredictable To ensure stable conditions to prevent haemodynamic destabilisation of patients, a variety of nursing care procedures is required, which in turn implies a high degree of specialisation.[8–10]

Patients transported by helicopter may suffer haemodynamic changes as a consequence of the HEMS transport itself, as it exposes the patient to physical situations that may predispose them to physiological alterations, accounting statistically for 13% of the morbidity.[9] The physiological functions that may be altered are: heart rate, blood pressure, oxygen saturation percentage, and their emotional state. This gives rise to a direct relationship between the haemodynamic changes experienced by the patient and the pathophysiology of their transport.[11–14]

Several publications show the benefits of medical helicopter transport compared to other types of transport, is spite of the fact that haemodynamic changes may occur during transport that will require to act accordingly. However, not many studies have been found describing haemodynamic changes in helicopter transport.

In this context, the objective of this review was to identify, synthesise, and assess the existing literature on haemodynamic changes in adult patients transported by HEMS.

Methods

Study Design

A literature review was conducted on haemodynamic changes during medical helicopter transport using the systematic review format by following the criteria of the updated PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.[15] The implemented protocol has been registered in the International Prospective Register of Systematic Reviews (PROSPERO) with code CRD42023470716.

Search Strategy

The formulation of the research question was based on the standardised PECOT structure (Table 1).

Research Question: What haemodynamic changes occur in adult patients transported by air in helicopters?

The following Medical Subject Headings (MeSH) descriptors were used to create the search string: Helicopter Emergency; Hemodynamics; and Transportation of Patients. In order to maximise the search, free terms were added to the search using the Boolean operators AND and OR (Table 2).

Table 3 shows the search process conducted on April 2023 in various databases (Pubmed, Scopus and Web of Science Complete) and the different search strings, filtering from January 2013 to April 2023.

Table 1 PECOT Format and Key Words

P: Population	Adult patients
E: Exposure	Helicopter transport
C: Comparison	Risk/protective factors
O: Outcomes	Haemodynamic changes
T: Time	During flight

Table 2 Terminology Used in the Search Strategy

MeSH	Keywords
Helicopter Emergency	Helicopter Emergency or Air ambulance or emergency care
Haemodynamics	Haemodynamics or monitoring haemodynamics
Transportation of Patients	Transportation of Patients

Table 3 Search Strategy in the Different Databases

Database	Search strategy	Date of search	Results
Pubmed	((helicopter[Title/Abstract] OR air plane[Title/Abstract] OR "Transportation of Patients"[Title/Abstract]) AND (emergenc*[Title/Abstract] OR critical*[Title/Abstract])) AND (hemodynamic*[Title/Abstract] OR hAemodynamic*[Title/Abstract] OR cardiovascular*[Title/Abstract] OR monitoring[Title/Abstract] OR "vital sign*"[Title/Abstract] OR cardiac[Title/Abstract])	20/04/2023	287
Scopus	Helicopter OR "air plane" OR "transportation of patients" AND emergenc* OR critical* h*emodynamic* OR cardiovascular* OR monitoring OR "vital sign*" OR cardiac	20/04/2023	1830
Web Of Science	Helicopter OR "air plane" OR "transportation of patients" (Topic) AND emergenc* OR critical* (Topic) AND h*emodynamic* OR cardiovascular* OR monitoring OR "vital sign*" OR cardiac (Topic)	20/04/2023	2000
Total			4117

Selection Criteria

The following inclusion and exclusion criteria were used for the selection of the articles:

Inclusion Criteria

- Articles published in English, Spanish, French, and Portuguese.
- Articles carried out between 2013 and 2023.
- Typology: descriptive studies, correlational studies, cohort or case-control studies.
- Articles assessing the following indicators: transport of adult patients by helicopter; in-flight haemodynamic changes such as blood pressure, oxygen saturation, and heart rate; in-flight, pre-flight, and post-flight assessment.

Exclusion Criteria

- Articles of low methodological quality after assessment applying the quality assessment tool.
- Articles on research involving pregnant women and children.
- Not related to the objective.
- Articles on military helicopters.

Data Collection and Extraction

The search was conducted independently by two reviewers using the agreed descriptors and the combination of Boolean operators indicated in the search strategy. Subsequently, the articles were read and selected according to the inclusion criteria and applying the exclusion criteria. In case of disagreements during the study selection and data extraction processes, a third reviewer acted as mediator to reach to a decision.

Methodological Quality Assessment

The assessment of methodological quality using a critical appraisal tool was carried out independently by both reviewers who applied the Joanna Briggs Institute (JBI) tool for studies at the University of Adelaide.[16] The use of this tool allows the assessment of the methodology used in the research by identifying the absence of bias in its design, procedure, or analysis. In the present review, the version for cross-sectional quantitative studies consisting of 8 items was used and the cut-off point was set by consensus of both researchers at 6/8 to be considered eligible for inclusion in the present review.

Regarding methodological quality assessment, the Newcastle-Ottawa scale was utilized. This scale evaluates three categories: Selection (with a maximum of 6 points), Comparability (with a maximum of 2 points), and Outcome (with a maximum of 5 points). Studies with 6 points or more suggest a good quality. Fair quality receives between 5 and 6 points. Poor quality is indicated from zero to two points. The included studies were scored from 8 to 9 points (Table 4).

Results

A total of 4117 articles were identified from the aforementioned databases using the search strings specified in Table 3. After removing duplicate articles 1112, a total of 3005 articles were identified. Then, 2771 articles were excluded after reading the title and abstract.

Subsequently, 96 articles were eliminated for different reasons after reading the full text. These included the type of study (n=65), low methodological quality (n=23), not being related to the objective of the review (n=22), reporting no or little data analysis (n=5), no details of the tool used (n=5), and not having the full text available (n=10). Figure 1 details the process followed for the identification, screening, and selection of the studies included in this review.

Finally, the articles included for review were 8, that reported haemodynamic changes in adult patients transported by helicopter.

Main Results

To synthesise the articles included in the review, a table has been drawn up which presents the main characteristics of the studies, including information on the author(s), location, main objective, type of research, sample, tools used, main results, and methodological quality (Table 5).[5,10,17–22]

Table 4 Methodological Quality Assessment and Quality of Evidence

Author, year	Selection	Comparability	Outcome	Methodological quality assessment
Slagt et al, 2022[17]	****	**	***	2++
Strony et al, 2022[18]	****	**	***	2++
Kawai et al, 2022[19]	****	**	***	2++
Leitch et al, 2021[20]	****	**	***	2+
Spoelder et al, 2022[21]	****	**	***	2++
Johannigman et al, 2015[22]	****	**	**	2+
Broman et al, 2015[10]	****	**	***	2++
Nozawa et al, 2020[5]	****	**	***	2++

Note: *indicates the number of points received in each category.

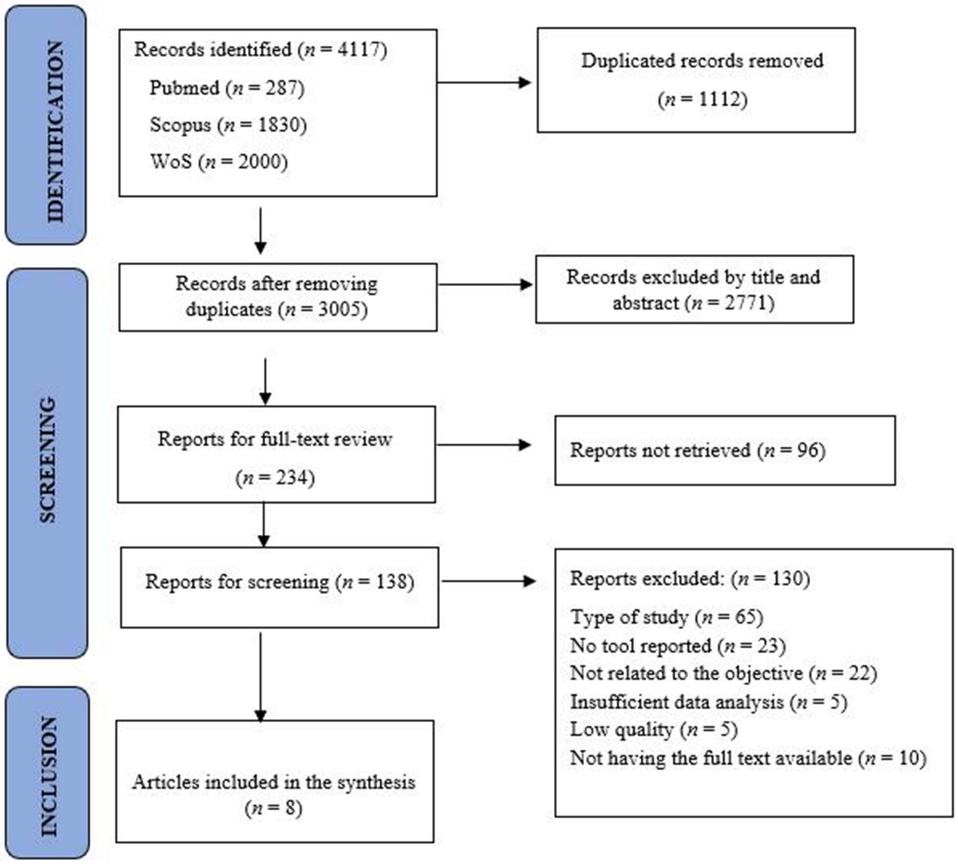

Figure 1 Identification of studies via databases (PRISMA Flowchart).
Note: Adapted from Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71.[15]

The origin of the different studies was varied: the studies had been conducted in the United States,[18,22] Japan,[5,19] United Kingdom,[21] the Netherlands,[17] Denmark,[10] and England,[20] one in each country; there were no multinational studies.

To summarise, all the articles reported on haemodynamic changes in vital signs during flight, such as blood pressure, heart rate, and oxygen saturation during HEMS missions; in one of them, the prevention of possible haemodynamic changes and instability through EFAST (Extended Focused Assessment with Sonography in Trauma) was also studied.[18]

Haemodynamic changes during HEMS missions were the main objective of the study and were assessed.[5,17–19]

In relation to the sample collection period, the studies were conducted in 2022,[18] 2015,[22] between 2020-2021,[17,21] between 2017-2020,[19] between 2014-2019,[20] between 2015-2019,[5] and between 2010-2013.[10]

Heart Rate

Heart rate has been one of the most studied variables by most researchers, obtaining very similar results as they coincide in that changes do exist. Slagt et al[17] analysed the variables that can be taken out of hospital to determine the increase in cardiac output at take-off and the decrease in systemic vascular resistance. Thus, this correlation was established based on the fact that there is a decrease in the heart rate during the flight. It should be noted that some patients required increased sedation.[21] A similarity exists with Strony et al,[18] where heart rate decreased during the flight, but increased before and after the flight. EFAST was used to assist in the presence of instability, in addition to cardiac monitoring.[17,18]

In the study by Nozawa et al,[4] the same changes were identified, where the heart rate increased during pre-flight and post-flight and decreased during the flight. This is consistent with the study by Spoelder[21] in which the results are similar.

However, there are studies in which stability was maintained, such as that by Kawai et al,[19] in which heart rate did not change significantly.

Table 5 Main Results

Studies	Context	Objectives of the study	Type of study	Participants	Instruments	Main results	JBI
Slagt et al, 2022[17]	Netherlands April 2020-June 2021The exposure time was 7451 min	To explore the impact of inter-hospital helicopter transfer on the vital signs of mechanically ventilated patients with severe COVID-19, with special emphasis on take-off, flight, and landing.	Descriptive cross-sectional study	98 ventilated critical care COVID-19 patients	Socio-demographic data, oral tube, Tracheostoma, Ventilation mode, Central venous catheter, Syringe pumps, and drug use	During take-off there were no significant changes in basic vital signs such as HR, CO_2, StO_2, and IAP. Mid-flight was the most stable time period with respect to vital signs; a difference over time was observed only for StO_2. At take-off, an increase in cardiac output (from 6.7 to 8.2 L min $^{-1}$; P < 0.0001) was observed, which was determined by a decrease in systemic vascular resistance (from 1071 to 739 dyn·cm^{-5}; P < 0.0001) accompanied by an increase in stroke volume (from 88.8 to 113.7 mL; P < 0.0001).	8/8
Strony et al, 2022[18]	February 2022 USA	To improve the control of pressure of EFAST examinations performed by HEMS teams following the implementation of a novel workflow to enable multi-faceted training and ensure continuous quality of care.	Descriptive cross-sectional study	175 patients with cardiovascular and respiratory pathology	Socio-demographic data EFAST POCUS	Applying the new EFAST testing method allows the HEMS team to assess pulmonary and cardiac status with 53% sensitivity and 98% specificity. It allows the HEMS team to quickly detect minimal alterations that threaten the haemodynamic status of the patient. Both heart rate and oxygen saturation decreased significantly during the flight, while systolic blood pressure increased.	7/8
Kawai et al, 2022[19]	March 2017 to June 2020 Japan	Comparison of changes in vital signs during ground and helicopter emergency medical services and hospital interventions.	Descriptive cross-sectional study	168 trauma patients	Socio-demographic data, medicine (beta blockers /antithrombotic therapy), trauma severity, transport methods, necessity of haemostatic treatment (haemostatic/IVR), 28-day mortality and vital signs measurements (heart rate, systolic blood pressure, respiratory rate and shock index)	Systolic blood pressure, respiratory rate, and shock index as measured in response to the interventions were calculated and divided by intervention time, and changes observed during the interventions were compared. Systolic blood pressure increased and shock index decreased after the HEMS intervention, while systolic blood pressure decreased and shock index increased during in-hospital interventions. Heart rate showed no significant changes (P = 0.12), and respiratory rate showed very slight changes. Systolic blood pressure increased significantly during the Hospital Emergency Medical Services interventions compared to the pre- and post-intervention periods.	7/8

Leitch et al, 2021[20]	England October 2014 to May 2019. The average time from PHEA to presentation in hospital was 59 min	Incidence of hyperoxia in trauma patients receiving pre-hospital emergency anaesthesia: results of a 5-year retrospective analysis.	Descriptive cross-sectional study	147 trauma patients with pre-hospital anaesthesia	Socio-demographic data, mechanism of injury, body regions injured, initial Glasgow Coma Score, PHEA pre-oxygenation- and apnoeic oxygenation, the occurrence of oxygen desaturations (SpO2 < 90%) peri- or post PHEA, FiO2 post intubation, time from PHEA to presentation in hospital and SpO2	Hyperoxia was defined as a PaO_2 > 16 kPA on the first arterial blood gas reading on arrival at major trauma centre. Most patients (90/147, 61.2%) had severe hyperoxia, while 30 patients (20.4%) had mild hyperoxia and 26 patients (19.7%) had normoxia. Only 1 patient (0.7%) presented hypoxia. PaO_2 median on the first arterial blood gas analysis (ABGA) after HEMS transfer was 36.7 [IQR 18.5–52.2] kPa, with a range of 7.0–86.0 kPa. Pulse oximetry readings of StO_2 before transfer were independently associated with the presence of hyperoxia. An $StO_2 \geq$ 97% was associated with a significantly increased odds of hyperoxia (OR 3.99 [1.58–10.08]), and had a sensitivity of 86.7% [79.1–92.4], a specificity of 37.9% [20.7–57.8], a positive predictive value of 84.5% [70.2–87.9], and a negative predictive value of 42.3% [27.4–58.7] for the presence of hyperoxaemia.	7/8
Spoelder et al, 2022[21]	United Kingdom March 2020-March 2021	Description of medical care in HEMS to a patient with COVID-19	Descriptive cross-sectional study	117 respiratory patients with mechanical ventilation	Socio-demographic data PICCO	Patients were airborne for 50 min (SD=15). During Tref, average MAP, SpO_2, HR and PET CO2 were 84 mmHg (95% CI=82–86), 93.8% (93.5–94.2), 83 bpm (79–87) and 42 mmHg (40–43), respectively. During Tair, these values decreased with 1.8 mmHg (1.2–2.5), 0.2% (0.1–0.3), 1.7 bpm (1.4–2.1) and 1.4 (1.3–1.6) mmHg, respectively. This applies to the point estimates as well as to the entire range of the 95% confidence intervals.	7/8
Johannian et al, 2015[22]	USA 2015	Description of medical care in aeromedical evacuation of a patient with traumatic injuries	Descriptive cross-sectional study	61 patients with traumatic injuries	Socio-demographic data PICCO	Patients were monitored before AE for a brief period, yielding a total recording time of 10.28 hours. The mean (SD) hemoglobin at the time of enrollment was 13.2 (3.5) g/dL (9.4–18.0 g/dL). Hypoxemia (SpO2 < 90%) was seen in 55 (90%) of 61 subjects. The mean duration of SpO2 less than 90% was 44 minutes. The mean (SD) change in SpO2 from baseline to mean in-flight SpO2 was 4% (1.2%). Thirty-four patients (56%) exhibited an SpO2 less than 85% for 11.7 (15) minutes.	7/8
Broman et al, 2015[10]	Denmark 2010–2013	Description of the experience of patients on ECMO transported by helicopter or on the ground.	Descriptive cross-sectional study	322 patients with refractory, severe respiratory, or/and circulatory failure ECMO	Socio-demographic data equipment and ECMO	Helicopter-transported patients showed haemodynamic changes with increasing oxygen saturation at take-off and landing and decreasing during the flight, requiring additional oxygen supply.	7/8

(*Continued*)

Table 5 (Continued).

Studies	Context	Objectives of the study	Type of study	Participants	Instruments	Main results	JBI
Nozawa et al, 2020[5]	Japan April 2015 and March 2019	Description of medical care in HEMS to a patient with stroke patients treated	Descriptive cross-sectional study	119 treated stroke patients	Socio-demographic data equipment and	The average BP of stroke patients increased after admission to the DH (before = 156.8 mm Hg and after = 165.0 mm Hg, P < 0.01). Both the infarct group and the bleeding group had elevated BP after admission (infarct group: before = 151.2 mm Hg and after = 157.8 mm Hg, P = 0.02; bleeding group: before = 167.5 mm Hg and after = 178.5 mm Hg, P = 0.04).	7/8

Abbreviations; EFAST: Extended Focused Assessment with Sonography in Trauma; fast echography. PICCO: Pulse Index Continuous Cardiac Output: a haemodynamic monitoring method, capable of measuring cardiac output by transpulmonary thermodilution (TDTP) and estimating preload by intrathoracic blood volume. ECMO: extracorporeal membrane oxygenation.

Blood Pressure

In the reviewed studies, changes in blood pressure have been observed mainly during flight. In the study by Nozawa et al,[5] diastolic blood pressure was maintained during take-off and landing and increased during the flight. Similarly, in the study by Slagt et al,[17] diastolic blood pressure increased during the flight, but systolic blood pressure also decreased during the flight in this study. In the research carried out by Spoelder,[21] blood pressure was not disaggregated, but there is a reported increase in blood pressure during the flight, which does not exist in pre-flight and post-flight. However, in a retrospective observational study by Kawai et al,[19] diastolic blood pressure increased post-flight and systolic blood pressure decreased.

Oxygen Saturation

Oxygen saturation showed very similar results across research, with the exception of patients on mechanical ventilation. Accordingly, in the study by Slagt et al,[17] there was no significant variation in StO_2 (oxygen saturation) levels. One factor to consider is that the flight altitude was at 800 and 1200 feet, where the application of physical laws results in little variation in StO_2, adding that the patients were on mechanical ventilation and therefore receiving extra oxygen supply.[17] In contrast, the research by Strony et al[18] found that StO_2 changed significantly, with a decrease during the flight phase and an increase during the pre-flight and post-flight phases. This is in discrepancy with the retrospective cohort study by Leicht et al,[20] where the patients arrived with hyperoxia. Yet, this was addressed by the transfer staff and under anaesthetic sedation, as 61% of the patients presented with severe hyperoxaemia, 20.4% with mild hyperoxaemia, and only 19.7% with normoxia. These measurements were accurate as they were made by means of arterial blood gas measurement, while peripheral oximetry readings showed $StO_2 \geq 97\%$.

Two studies reported similar outcomes, the one by Spoelder,[21] in which StO_2 decreased during flight and increased during pre-flight and post-flight, and the study by Broman et al,[10] in which StO_2 increased during pre-flight and post-flight and decreased during flight.

In contrast to the rest of the studies, the one by Kawai et al[19] was the only one in which a small increase in respiratory rate during transport was assessed.

Discussion

In this review, we use the acronym PECOT (Population, Exposure, Comparator, Outcomes, Time) to address haemodynamic changes in adult patients transported by the Helicopter Emergency Medical Service. The changes were assessed during pre-flight (before the helicopter took off), during the flight (when the helicopter was in continuous flight), and post-flight (when the aircraft landed). Potential medical risks from exposure to high altitude during flight and travelling at high speeds on board an aircraft are among the factors contributing to physiological changes.[6,23]

Many epidemiological studies have described out-of-hospital emergency health care, mainly regarding ground transport, but very few have referred exclusively to emergency medical air transport. HEMS offers many benefits, including the ability to quickly access rural or remote locations, provide multiple advanced on-board configurations, and intervene when ground units are unavailable. Other considerations for the use of HEMS include changes in physiology associated with the flight.[24,25]

The analysed studies showed, as the main haemodynamic modification, changes in heart rate, blood pressure, and oxygen saturation.

Oxygen saturation is predisposed to change, and oxygen compensation mechanisms must be in place to avoid developing other pathologies during the helicopter transport. Atmospheric pressure decreases with increasing altitude, with a consequent decrease in oxygen partial pressure, causing hypoxia. Hypoxia can be defined as a deficiency of oxygen in body tissues sufficient to cause impairment of the physiological function.[9,26] The most threatening aspect of hypoxia is its insidious onset. It is taken for granted that Gay Lussac's physical law, Charles' Law, and Boyle's Law (which can be observed when a person inflates a balloon because, if there is more pressure exerted inside the balloon, its volume increases),[19] will be observed in patients who are transported by helicopter as they will obviously be flying at a height above the sea level.[3,27,28]

The research conducted by Thomas et al[29] in which 30 patients were transported on different modes of invasive mechanical ventilation, 10 of them on Oxilog® ventilators, showed variations in oxygen saturation due to a failure in the ventilator that failed to favour minute volume, causing hyperventilation in these patients. However, in the study by Strony et al,[18] of 28 patients who were intubated and connected to an Oxilog®-type ventilator during patient transport, 43% of them suffered alterations in oxygen saturation during the flight, recovering their baseline state once they arrived at their destination.

According to the study conducted by Andrews et al,[30] patients who were transported suffered haemodynamic changes before, during, and after transport in a proportion of 80% of the total, of which 51% of patients suffered these changes during transport and 66% of patients suffered them prior to transport. This leads to the conclusion that in order for the haemodynamic changes in the patients not to be further aggravated during transport, this should be started with as much stabilisation as possible and under proper haemodynamic control.

Blood pressure plays an important role in helicopter transport since, according to evidence, minimal changes in blood pressure are observed, mainly with a tendency to increase systolic blood pressure during the flight as a response to physiological stress and hypoxia, which requires careful monitoring to prevent complications.[29,31,32]

Regarding heart rate, we observed that it undergoes relevant changes with a downward trend during the flight and increasing before and after the flight without causing tachycardia, however in the study by Taylor carried out in which he had a sample of 50 patients of which, 42 presented cardiac arrhythmias with tendencies towards tachycardia during the transfer, and 22 of them were considered serious, deducing that the mere fact of transferring patients already produced interaction in the changes in heart rate.[25]

There are studies that, although they do not involve emergency helicopters, are relevant to our study. They showed that haemodynamic and physiological changes were observed in patients with different pathologies who were transported intra-hospital. 66% of the patients transferred from the ICU for tests experienced physiological changes before, during, and after the transfer, but these changes were not due to the physiopathology of the transport, but to the severity of the patient's illness.[32]

The vehicle dynamics on the transported patient have an influence on their health status. Specifically, linear accelerations can increase blood pressure and could cause rapid changes in heart rate and blood pressure.[33] Thus, the importance of monitoring and managing hemodynamic changes during HEMS transportation is noted in this study. HEMS teams are likely not only provide advanced clinical skills, but also to support clinical decision-making in terms of triage and transport conditions. In this sense, in order to maintaining hemodynamic control, the immediate identification of blood loss, pneumothorax, and cardiovascular diseases via ultrasound examinations is known to be effective for patients with trauma and cardiovascular diseases in prehospital settings.[34,35] Indeed, out-of-hospital standards of monitoring should not be interrupted at any time, so that patients can be safely transported.[36] Also, high-fidelity invasive arterial blood pressure monitoring and arterial blood gas analysis become relevant in the HEMS prehospital setting to assure a safe transportation.[37]

Among the limitations of the study, the difficulty in selecting articles related to medical helicopter transport and its relationship with haemodynamic changes, as well as the relationship between air transport in terms of each pathology and the meteorological and physical parameters physiological variables involved, such as altitude, vibrations, temperature, etc., were addressed. Also, the selected studies had a cross-sectional design which avoid generalizations or conclusions about prevalence.

Conclusion

Based on the available literature, it can be concluded that the haemodynamic changes that occur during HEMS missions modify most notably heart rate, blood pressure, and oxygen saturation. These parameters physiological variables remain similar during take-off and landing and decrease during the flight, thus applying the laws of physics.

Ill patients benefit from medical transport by helicopter, especially when they are in areas far from a reference hospital. It would be interesting to carry out more studies on this subject, in order to increase the knowledge of health professionals on the matter. In clinical practice, the different emergency services should also carry out studies on the activity of their HEMS, both in first response and in interhospital transfer, taking into account pathologies, and monitoring of vital signs.

Key Points

Question

Not many studies have been found describing haemodynamic changes in helicopter transport. In this context, the objective of this review was to describe haemodynamic changes in adult patients transported by Helicopter Emergency Medical Services.

Findings

Haemodynamic changes that occur during HEMS missions modify most notably heart rate, blood pressure, and oxygen saturation. These parameters physiological variables remain similar during take-off and landing and decrease during the flight, except for blood pressure, which rises during the flight, thus applying the laws of physics.

Meaning

Healthcare HEMS professionals must be aware of these alterations of in order to assess the appropriateness of the transport and apply optimal care.

Abbreviations

EFAST, Extended Focused Assessment with Sonography in Trauma; HEMS, Helicopter Emergency Medical Services; JBI, Joanna Briggs Institute; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; PROSPERO, Prospective Register of Systematic Reviews; StO_2, Oxygen Saturation.

Data Sharing Statement

All data are available within this article.

Author Contributions

Conceptualization, AAG, JGS, FJFC, JMVL, JJGI, BMY, FJMV, LRD.
Data curation, AAG, JGS, FJFC, JMVL, JJGI, BMY, FJMV, LRD.
Formal analysis, AAG, JGS, FJFC, JMVL, JJGI, BMY, FJMV, LRD.
Investigation, AAG, JGS, FJFC, JMVL, JJGI, BMY, FJMV, LRD.
Methodology, AAG, JGS, FJFC, JMVL, JJGI, BMY, FJMV, LRD.
Project administration, AAG, LRD.
Resources, AAG, JGS, FJFC, JMVL, JJGI, BMY, FJMV, LRD.
Software, AAG, JGS, FJFC, JMVL, JJGI, BMY, FJMV, LRD.
Supervision, AAG, JGS, FJFC, JMVL, JJGI, BMY, FJMV, LRD.
Validation, AAG, JGS, FJFC, JMVL, JJGI, BMY, FJMV, LRD.
Visualization, AAG, JGS, FJFC, JMVL, JJGI, BMY, FJMV, LRD.
Writing—original draft preparation, AAG, JGS, FJFC, JMVL, JJGI, BMY, FJMV, LRD.
Writing—review and editing, AAG, JGS, FJFC, JMVL, JJGI, BMY, FJMV, LRD.
All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

The authors declare the non-existence of funding in relation to this article.

Disclosure

The authors declare that they have no conflicts of interest in relation to this article.

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