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Research Article

Standardized Fitness-to-Fly Assessment for Neurosurgical Patient Repatriation from the United Arab Emirates : A Comprehensive Framework

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Abstract

Background: The United Arab Emirates (UAE) has a large expatriate population, with approximately 88% of residents being non-nationals. This demographic reality creates a significant need for international patient repatriation following neurosurgical interventions. Despite this need, there is a lack of standardized guidelines for assessing fitness-to-fly in neurosurgical patients requiring repatriation.

Objective: To develop a comprehensive framework and condition-specific protocols for assessing fitness-to-fly in neurosurgical patients requiring repatriation from UAE hospitals to their home countries.

Methods: A systematic review of literature on aeromedical evacuation of neurosurgical patients was conducted, followed by analysis of current repatriation forms and policies. Based on this research, a standardized assessment framework and condition-specific protocols were developed for five common neurosurgical conditions: post-operative cases, traumatic brain injury, stroke, cerebrospinal fluid leaks, and spinal injuries. The framework was validated through expert review by senior neurosurgeons with experience in international patient transfers.

Results: The research identified significant gaps in existing repatriation guidelines for neurosurgical patients. The developed framework addresses these gaps through a comprehensive assessment approach that considers physiological, logistical, and condition-specific factors. Condition-specific protocols provide detailed guidance on timing considerations, critical assessment parameters, and transport method selection.

Conclusion: The standardized assessment framework and condition-specific protocols presented in this paper provide UAE neurosurgeons with evidence-based tools for evaluating fitness-to-fly in neurosurgical patients requiring repatriation. Implementation of these guidelines can improve patient safety during repatriation while standardizing the assessment process across practitioners.

Keywords: Neurosurgery; Patient Repatriation; Aeromedical Evacuation; Fitness-To-Fly; United Arab Emirates; Expatriate Healthcare; Air Travel; Medical Clearance

Introduction

Expatriates in the United Arab Emirates represent about 88% of the population, while Emiratis constitute roughly 12% of the total population, making the UAE home to the world's highest percentage of expatriates after the Vatican City [1,2], 2. This demographic reality creates unique challenges for the healthcare system, particularly in the management of patients requiring specialized neurosurgical care. Following neurosurgical interventions or in cases of

neurological emergencies, many expatriate patients require repatriation to their home countries for continued care, rehabilitation, or family support.

Neurosurgical patients present distinct challenges during air travel due to the physiological effects of altitude, cabin pressure changes, and limited access to specialized medical care during flight. These challenges are particularly relevant for patients with recent craniotomies, traumatic brain injuries, strokes, cerebrospinal fluid leaks, and spinal injuries. Despite the frequency of such repatriations from UAE hospitals, there is a notable absence of standardized guidelines for assessing fitness-to-fly in these patients.

Currently, neurosurgeons in the UAE must complete various airline medical forms to certify a patient's fitness for air travel, but these forms lack specific criteria for neurosurgical conditions. This gap in standardization can lead to inconsistent assessment practices, potential delays in repatriation, or, conversely, premature clearance for air travel with associated risks [3].

The aim of this research is to develop a comprehensive framework and condition-specific protocols for assessing fitness-to-fly in neurosurgical patients requiring repatriation from UAE hospitals. This framework focuses on five common neurosurgical conditions identified as frequent causes for repatriation: post-operative cases, traumatic brain injury, stroke, cerebrospinal fluid leaks, and spinal injuries. By providing standardized assessment criteria and decision-making tools, this research addresses a significant gap in current practice and aims to improve patient safety during repatriation.

Methodology

The development of the standardized assessment framework and condition-specific protocols followed a structured approach:

- **Literature Review:** A comprehensive review of published literature on aeromedical evacuation of neurosurgical patients was conducted, focusing on physiological considerations, timing recommendations, and risk factors. The review included articles published between 2000-2023, with emphasis on the most recent evidence where available.
- **Analysis of Current Forms and Policies:** Existing airline medical clearance forms and aeromedical evacuation policies were analyzed to identify gaps and limitations when applied to neurosurgical patients. Special attention was given to forms used by major UAE-based airlines (Emirates and Etihad Airways).
- **Framework Development:** Based on the literature review and analysis of current forms, a standardized assessment framework was developed to address the specific needs of neurosurgical patients requiring repatriation.
- **Protocol Development:** Condition-specific protocols were developed for five common neurosurgical conditions: post-operative cases, traumatic brain injury, stroke, CSF leaks, and spinal injuries.
- **Expert Validation:** The proposed framework and protocols were reviewed by a panel of two senior neurosurgeons and 4 physician who work in airport clinic. Their feedback was incorporated into the final version of the framework and protocols.

The resulting framework and protocols were designed to be comprehensive yet practical for implementation in clinical settings, with specific consideration for the UAE healthcare context and common repatriation destinations.

Physiological considerations in air travel for neurosurgical patients

Commercial aircraft typically cruise at altitudes between 30,000 and 40,000 feet, where the atmospheric pressure is significantly lower than at sea level. While aircraft cabins are pressurized, they are typically maintained at a pressure equivalent to 6,000-8,000 feet above sea level [4].

This reduced pressure environment has several physiological implications for neurosurgical patients:

Gas expansion

According to Boyle's Law, as atmospheric pressure decreases, gas volume increases. For neurosurgical patients, this can lead to expansion of intracranial air (pneumocephalus), potentially causing increased intracranial pressure and neurological deterioration [5]. Recent studies by Bichsel et al. (2022) have demonstrated that even small amounts of pneumocephalus can expand by up to 30% during air travel, potentially causing significant neurological compromise [5]. Research by Josephs et al. has further shown that even minor changes in pressure can significantly increase intracranial pressure in vulnerable patients [15].

Hypoxemia

The partial pressure of oxygen decreases at altitude, potentially leading to hypoxemia. Patients with compromised cerebral perfusion or recent neurological injury may be particularly vulnerable to even mild hypoxemia [4]. Netzer et al. demonstrated that altitude exposure can lead to significant decreases in arterial oxygen saturation, which may be poorly tolerated in neurosurgically compromised patients [6].

Cerebral blood flow changes

Hypoxemia can trigger compensatory increases in cerebral blood flow, which may be problematic in patients with recent intracranial procedures or injuries [6]. This physiological response can potentially exacerbate cerebral edema or increase the risk of hemorrhage in vulnerable patients.

Venous stasis

Adi et al. concluded that no definitive evidence exists that prolonged (more than 3-hours) travel including air travel, increases the risk of DVT. However, there is evidence to suggest that flights of eight hours or more increase the risk of DVT if additional risk factors exist [7]. This is particularly relevant for neurosurgical patients, who often have multiple risk factors for thromboembolism, including immobility, recent surgery, and in some cases, underlying hypercoagulable states.

Current practices and gaps in assessment

Current aeromedical evacuation practices

The International Air Transport Association (IATA) has developed a standardized Medical Information Form (MEDIF) that is widely used by airlines to assess a passenger's fitness to fly. However, this form provides only general guidance and lacks specific criteria for neurosurgical conditions [8].

Several studies have examined the safety of air travel for specific neurosurgical conditions. Donovan et al. examined the repatriation of post-operative neurosurgical patients and identified key risk factors including the presence of pneumocephalus, elevated intracranial pressure, and recent seizure activity [9].

Despite these studies, there remains a lack of comprehensive guidelines specifically addressing the repatriation of neurosurgical patients from regions with high expatriate populations like the UAE. The existing literature primarily focuses on emergency evacuations rather than elective repatriation of stabilized patients, which represents a significant proportion of cases in the UAE context.

Gaps in current assessment forms and policies

Analysis of current airline medical clearance forms reveals several limitations when applied to neurosurgical patients:

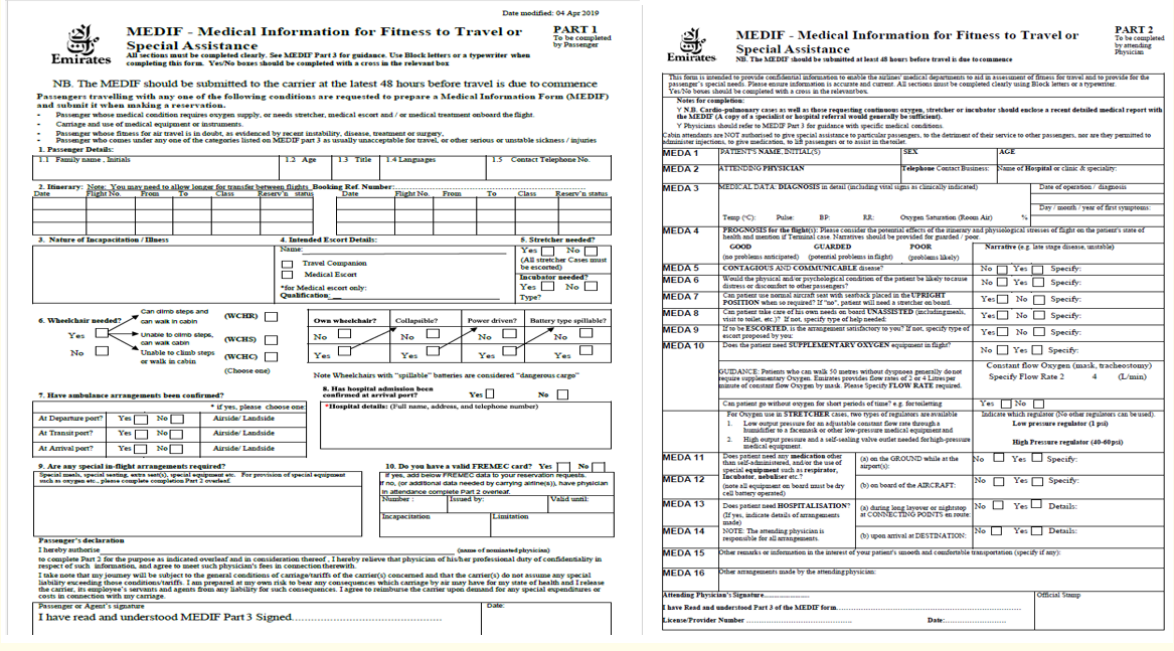
- **Lack of Neurosurgical Specificity:** Most forms use general medical criteria without specific neurosurgical assessment parameters.
- **Inconsistent Standards:** Different airlines and countries have varying requirements for medical clearance.
- **Limited Guidance for Physicians:** Insufficient detailed protocols for assessing fitness to fly for specific neurosurgical conditions.
- **No Standardized Approach for UAE Context:** No specific guidelines addressing the common repatriation routes from UAE to countries like India, Pakistan, Bangladesh, Philippines, and Arab countries.

- **Inadequate Assessment for CSF Leaks:** Limited guidance on evaluating patients with CSF leaks for air travel.
- **Minimal Spinal Injury Protocols:** Insufficient specific guidelines for different types of spinal injuries.

These gaps highlight the need for a comprehensive, standardized approach to assessing fitness-to-fly in neurosurgical patients requiring repatriation from UAE hospitals.

UAE airline medical forms for neurosurgical patient repatriation

Emirates airlines medif (medical information for fitness to travel)



Date modified: 04 Apr 2019

MEDIF - Medical Information for Fitness to Travel or Special Assistance — PART 1

NB. The MEDIF should be submitted to the carrier at the latest 48 hours before travel is due to commence

MEDIF - Medical Information for Fitness to Travel or Special Assistance — PART 2

Figure a

Emirates Airlines, the UAE's largest carrier, utilizes a standardized Medical Information Form (MEDIF) to assess passengers' fitness to travel. This form is particularly relevant for neurosurgical patients requiring repatriation from UAE hospitals. The Emirates MEDIF consists of three pages and must be submitted at least 48 hours before travel is due to commence.

Key components of the Emirates MEDIF include:

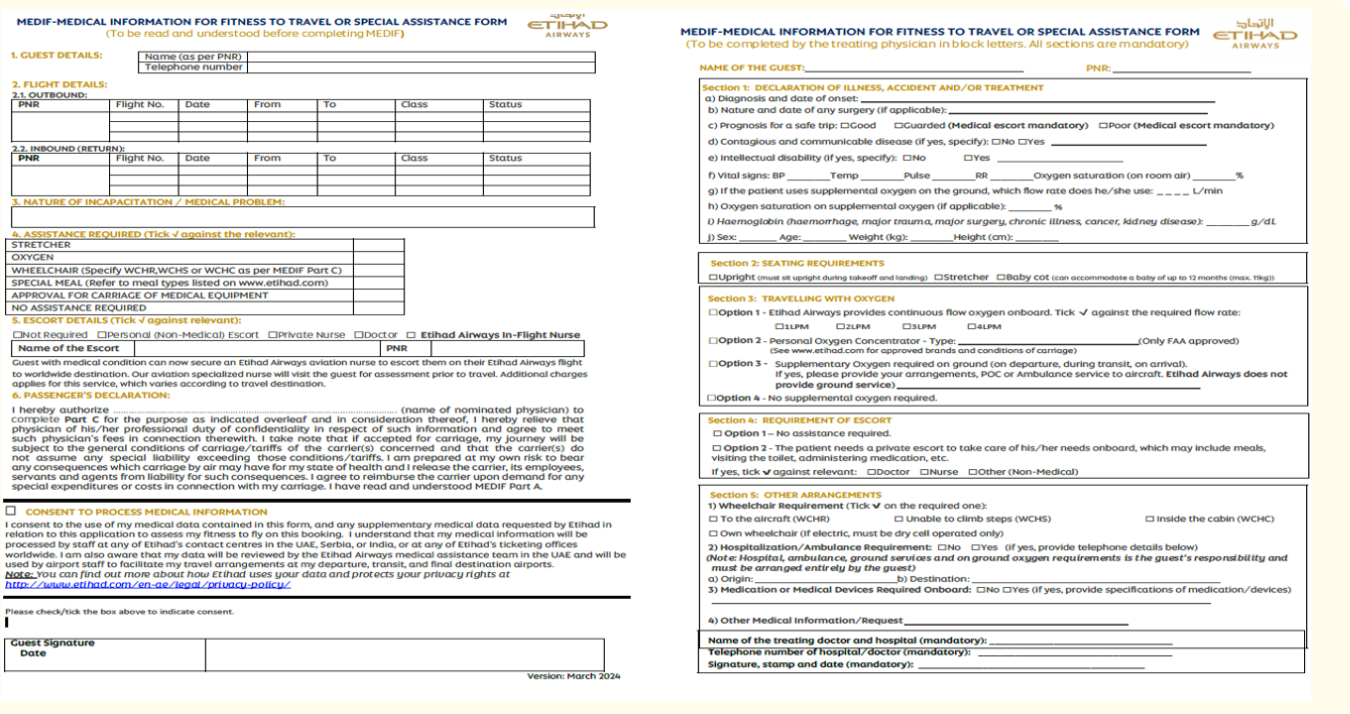
- **Patient Information Section:** Captures basic demographic details, contact information, and flight itinerary.
- **Nature of Incapacitation/Illness:** This section requires detailed information about the neurosurgical condition, which is critical for proper assessment of fitness-to-fly. For neurosurgical patients, this should include specific diagnosis, date of surgery/injury, current neurological status, and any special considerations.
- **Escort Details:** Specifies whether the patient requires a medical escort or travel companion, which is often necessary for neurosurgical patients, particularly those with traumatic brain injury or recent post-operative status.

- **Mobility Assessment:** Includes detailed questions about wheelchair requirements and mobility capabilities, which are particularly relevant for patients with spinal injuries.
- **Special Equipment Requirements:** Documents any medical equipment needed during the flight, such as oxygen supply, which may be necessary for patients with compromised respiratory function secondary to neurological conditions.
- **Hospital Admission Arrangements:** Confirms whether hospital admission has been arranged at the destination, which is essential for continuity of care in neurosurgical patients.

The Emirates MEDIF specifically states that passengers with the following conditions are requested to prepare a MEDIF:

- Passengers whose medical condition requires oxygen supply, stretcher, medical escort, or medical treatment onboard
- Carriage and use of medical equipment or instruments
- Passengers whose fitness for air travel is in doubt due to recent instability, disease, treatment, or surgery
- Passengers who fall under categories listed in MEDIF part 3 (which includes conditions that are usually unacceptable for travel)
- For neurosurgical patients, the Emirates MEDIF lacks specific assessment criteria for conditions such as pneumocephalus, elevated intracranial pressure, or CSF leaks, which are critical considerations for these patients' fitness to fly. This gap highlights the need for the standardized assessment framework proposed in this paper.

Etihad airways MEDIF



MEDIF-MEDICAL INFORMATION FOR FITNESS TO TRAVEL OR SPECIAL ASSISTANCE FORM

(To be read and understood before completing MEDIF)

1. GUEST DETAILS:

Name (as per PNR)	
Telephone number	

2. FLIGHT DETAILS:

2.1. OUTBOUND:

PNR	Flight No.	Date	From	To	Class	Status

2.2. INBOUND (RETURN):

PNR	Flight No.	Date	From	To	Class	Status

3. NATURE OF INCAPACITATION / MEDICAL PROBLEM:

4. ASSISTANCE REQUIRED (Tick √ against the relevant):

STRETCHER	
OXYGEN	
WHEELCHAIR (Specify WCHR,WCHS or WCHC as per MEDIF Part C)	
SPECIAL MEAL (Refer to meal types listed on www.etihad.com)	
APPROVAL FOR CARRIAGE OF MEDICAL EQUIPMENT	
NO ASSISTANCE REQUIRED	

5. ESCORT DETAILS (Tick √ against relevant):

☐Not Required ☐Personal (Non-Medical) Escort ☐Private Nurse ☐Doctor ☐ **Etihad Airways In-Flight Nurse**

Name of the Escort		PNR	

Guest with medical condition can now secure an Etihad Airways aviation nurse to escort them on their Etihad Airways flight to worldwide destination. Our aviation specialized nurse will visit the guest for assessment prior to travel. Additional charges applies for this service, which varies according to travel destination.

6. PASSENGER'S DECLARATION:

I hereby authorize ..... (name of nominated physician) to complete **Part C** for the purpose as indicated overleaf and in consideration thereof, I hereby relieve that physician of his/her professional duty of confidentiality in respect of such information and agree to meet such physician's fees in connection therewith. I take note that if accepted for carriage, my journey will be subject to the general conditions of carriage/tariffs of the carrier(s) concerned and that the carrier(s) do not assume any special liability exceeding those conditions/tariffs. I am prepared at my own risk to bear any consequences which carriage by air may have for my state of health and I release the carrier, its employees, servants and agents from liability for such consequences. I agree to reimburse the carrier upon demand for any special expenditures or costs in connection with my carriage. I have read and understood MEDIF Part A.

☐ CONSENT TO PROCESS MEDICAL INFORMATION

I consent to the use of my medical data contained in this form, and any supplementary medical data requested by Etihad in relation to this application to assess my fitness to fly on this booking. I understand that my medical information will be processed by staff at any of Etihad's contact centres in the UAE, Serbia, or India, or at any of Etihad's ticketing offices worldwide. I am also aware that my data will be reviewed by the Etihad Airways medical assistance team in the UAE and will be used by airport staff to facilitate my travel arrangements at my departure, transit, and final destination airports.

Note: You can find out more about how Etihad uses your data and protects your privacy rights at http://www.etihad.com/en-ae/legal/privacy-policy/

Please check/tick the box above to indicate consent.

Guest Signature	
Date	

Version: March 2024

MEDIF-MEDICAL INFORMATION FOR FITNESS TO TRAVEL OR SPECIAL ASSISTANCE FORM

(To be completed by the treating physician in block letters. All sections are mandatory)

NAME OF THE GUEST:_____ PNR: _____

Section 1: DECLARATION OF ILLNESS, ACCIDENT AND/OR TREATMENT

a) Diagnosis and date of onset: _____

b) Nature and date of any surgery (if applicable): _____

c) Prognosis for a safe trip: ☐Good ☐Guarded (**Medical escort mandatory**) ☐Poor (**Medical escort mandatory**)

d) Contagious and communicable disease (if yes, specify): ☐No ☐Yes _____

e) Intellectual disability (if yes, specify): ☐No ☐Yes _____

f) Vital signs: BP _____Temp _____Pulse _____RR _____Oxygen saturation (on room air) _____%

g) If the patient uses supplemental oxygen on the ground, which flow rate does he/she use: _ _ _ _ L/min

h) Oxygen saturation on supplemental oxygen (if applicable): _____ %

i) *Haemoglobin (haemorrhage, major trauma, major surgery, chronic illness, cancer, kidney disease):* _____g/dL

j) Sex: _____ Age: _____Weight (kg): _____Height (cm): _____

Section 2: SEATING REQUIREMENTS

☐Upright (must sit upright during takeoff and landing) ☐Stretcher ☐Baby cot (can accommodate a baby of up to 12 months (max. 11kg))

Section 3: TRAVELLING WITH OXYGEN

☐**Option 1** - Etihad Airways provides continuous flow oxygen onboard. Tick ✓ against the required flow rate:

☐1LPM ☐2LPM ☐3LPM ☐4LPM

☐**Option 2** - Personal Oxygen Concentrator - Type: _____(Only FAA approved)

(See www.etihad.com for approved brands and conditions of carriage)

☐**Option 3** - Supplementary Oxygen required on ground (on departure, during transit, on arrival).

If yes, please provide your arrangements, POC or Ambulance service to aircraft. **Etihad Airways does not provide ground service)** _____

☐**Option 4** - No supplemental oxygen required.

Section 4: REQUIREMENT OF ESCORT

☐ **Option 1** – No assistance required.

☐ **Option 2** - The patient needs a private escort to take care of his/her needs onboard, which may include meals, visiting the toilet, administering medication, etc.

If yes, tick ✓ against relevant: ☐Doctor ☐Nurse ☐Other (Non-Medical)

Section 5: OTHER ARRANGEMENTS

1) **Wheelchair Requirement** (Tick ✓ on the required one):

☐ To the aircraft (WCHR) ☐ Unable to climb steps (WCHS) ☐ Inside the cabin (WCHC)

☐ Own wheelchair (if electric, must be dry cell operated only)

2) **Hospitalization/Ambulance Requirement:** ☐No ☐Yes (if yes, provide telephone details below)

(Note: Hospital, ambulance, ground services and on ground oxygen requirements is the guest's responsibility and must be arranged entirely by the guest)

a) Origin: _____b) Destination: _____

3) **Medication or Medical Devices Required Onboard:** ☐No ☐Yes (if yes, provide specifications of medication/devices)

_____

4) **Other Medical Information/Request** _____

Name of the treating doctor and hospital (mandatory): _____

Telephone number of hospital/doctor (mandatory): _____

Signature, stamp and date (mandatory): _____

Figure b

Etihad Airways, the second-largest airline in the UAE, also employs a Medical Information Form for assessing fitness to travel. The Etihad MEDIF must be submitted along with the latest medical report from the treating physician at least 72 hours before departure, but not more than 14 days prior to the commencement date of travel.

Key features of the Etihad Airways MEDIF include

- **Guidance for Doctors:** The form provides specific guidance for physicians on the physiological considerations of air travel, including:
  - Reduction in atmospheric pressure with resultant gaseous expansion
  - Reduction in oxygen partial pressure (cabin is pressurized to an altitude equivalent of 6,000 to 8,000 feet)
  - Specific considerations for patients with cardiorespiratory disease or anemia
- **Conditions Requiring Medical Clearance:** Etihad Airways explicitly lists conditions that require medical clearance, including:
  - Contagious and communicable diseases
  - Physical or behavioral conditions that may pose a hazard to other guests
  - Conditions that may be adversely affected by the flight environment
  - Unstable physical or psychological conditions
  - Requirements for in-flight oxygen or personal oxygen concentrators
  - Need for battery-powered medical equipment
- **Therapeutic Oxygen Information:** Detailed information about onboard oxygen service, which is particularly relevant for neurosurgical patients who may require supplemental oxygen due to compromised respiratory function.
- **Medical Assistive Devices:** Guidelines for the use of personal electronic respiratory assistive devices, which may be necessary for some neurosurgical patients with respiratory complications.

Similar to the Emirates MEDIF, the Etihad form lacks neurosurgical-specific assessment criteria, reinforcing the need for the specialized framework proposed in this research.

Comparison and limitations for neurosurgical patients

Both Emirates and Etihad MEDIFs share several limitations when applied to neurosurgical patients:

- **Lack of Neurosurgical Specificity:** Neither form includes specific assessment parameters for common neurosurgical conditions such as post-craniotomy status, traumatic brain injury, or CSF leaks.
- **Insufficient Timing Guidelines:** The forms do not provide guidance on appropriate waiting periods after neurosurgical procedures or injuries before air travel is safe.
- **Limited Neurological Assessment:** There are no specific sections for documenting neurological status or changes, which are critical for neurosurgical patients.
- **Inadequate Risk Stratification:** The forms do not facilitate risk stratification based on neurosurgical condition severity or specific risk factors.

These limitations underscore the importance of the standardized assessment framework and condition-specific protocols developed in this research, which can complement existing airline medical forms to ensure comprehensive evaluation of neurosurgical patients' fitness to fly.

Standardized assessment framework

The standardized assessment framework provides a structured approach for evaluating fitness-to-fly in neurosurgical patients requiring repatriation. The framework consists of nine key sections:

Patient information and demographics

This section captures essential patient information, including nationality, destination country, and receiving facility details. This information is particularly important in the UAE context, where patients are being repatriated to diverse countries with varying healthcare capabilities.

Neurosurgical condition assessment

This section documents the primary diagnosis, date of surgery/injury/diagnosis, current clinical status, and relevant imaging findings. It provides a comprehensive overview of the patient's neurosurgical condition to inform the fitness-to-fly assessment.

Medical stability assessment

This section evaluates the patient's overall medical stability, including hemodynamic status, respiratory status, seizure status, and comorbidities. Medical stability is a prerequisite for any form of air travel and must be thoroughly assessed.

Flight-specific risk assessment

This section addresses specific risks associated with the flight environment, including cabin pressure considerations, mobility and positioning needs, special equipment requirements, and potential in-flight complications.

Repatriation timing assessment

This section provides guidance on appropriate timing for repatriation based on the specific neurosurgical condition, with consideration for the optimal waiting period after surgery or injury.

Transport method recommendation

This section guides the selection of appropriate transport method (commercial airline with/without medical escort, air ambulance) based on the patient's condition and risk assessment.

Pre-flight preparation checklist

This section ensures all necessary preparations are completed before the patient's journey, including required documentation, medical supplies, and patient/family preparation.

Final clearance and physician declaration

This section provides a structured format for the final fitness-to-fly assessment and physician declaration, including risk stratification and specific recommendations.

Post-clearance coordination

This section addresses the logistical aspects of repatriation, including airline notification, receiving facility coordination, and transport logistics.

Condition-specific protocols

Building on the standardized assessment framework, condition-specific protocols were developed for five common neurosurgical conditions requiring repatriation from UAE hospitals.

Post-operative neurosurgical patients

Timing considerations

- **Craniotomy/Craniectomy:** Minimum wait period of 10-14 days from date of surgery, with optimal wait period of 14-21 days.
- **Burr Hole Procedures:** Minimum wait period of 7-10 days, with optimal wait period of 10-14 days.
- **Transsphenoidal Surgery:** Minimum wait period of 14-21 days, with absolute contraindication for any evidence of ongoing CSF leak.
- **Ventriculoperitoneal Shunt Placement:** Minimum wait period of 7-10 days, with consideration for shunt function assessment prior to flight.

These timing recommendations are based on studies by Amato-Watkins., *et al.* [10] and expert consensus from our validation panel. It should be noted that individual patient factors may necessitate longer waiting periods in some cases.

Critical assessment parameters

- **Wound Healing:** Complete healing is optimal for air travel; partial healing may be acceptable with appropriate wound care plan.
- **Pneumocephalus:** Presence of pneumocephalus is an absolute contraindication to commercial air travel.
- **Intracranial Pressure:** Normal intracranial pressure is required for safe air travel; elevated ICP is a contraindication.
- **Neurological Status:** Clinical stability for >72 hours is required for consideration of air travel. Stability is defined as no new neurological deficits, no deterioration in existing deficits, and no requirement for escalation of medical management.

Traumatic brain injury patients

Timing considerations

- **Mild TBI (GCS 13-15):** Minimum wait period of 7-10 days from injury or resolution of symptoms.
- **Moderate TBI (GCS 9-12):** Minimum wait period of 14-21 days from injury.

- **Severe TBI (GCS 3-8):** Minimum wait period of 21-28 days from injury.
- **TBI Requiring Surgical Intervention:** Follow post-operative protocol timing in addition to TBI considerations.

These recommendations align with findings from Goodman., *et al*. [11], who demonstrated that premature air travel after TBI was associated with increased risk of neurological deterioration.

Critical assessment parameters

- Intracranial Pressure: Normal intracranial pressure for >72 hours is required for commercial flight consideration. Air travel can lead to changes in atmospheric pressure, which may exacerbate intracranial hypertension. While specific studies directly linking ICP stability to air travel readiness are limited, expert consensus suggests that patients should be observed until sufficient time has passed to ensure the stability of their neurological condition before flying [12]. Research by Alali et al. has demonstrated that proper ICP monitoring and management significantly improves outcomes in patients with severe TBI, underscoring the importance of confirmed ICP normalization before air travel [14].
- Cerebral Edema: Presence of cerebral edema is a contraindication to commercial air travel. Flying can increase intracranial pressure and put the individual's life at risk. As the plane ascends, the air pressure decreases, allowing brain fluids to expand, which can exacerbate cerebral edema [12].
- Hemorrhage Evolution: Stability for >72 hours is required for consideration of repatriation. Ensuring stability for more than 72 hours after a hemorrhagic event before considering air travel is advisable. Frequent neurological assessment is reasonable for up to 72 hours after admission to detect early neurological deterioration [12].
- Neurological Status: Stability for >72 hours is required for consideration of air travel. Stability in neurological status for over 72 hours is a reasonable criterion before considering air travel. The Aerospace Medical Association recommends that individuals who have had a recent stroke or near-stroke should not travel by air until the acute phase has passed and the condition is stable as determined by the managing physician [4].

Stroke patients

Timing considerations

- **Ischemic Stroke:** Minimum wait period of 14 days from stroke onset for uncomplicated cases.
- **Hemorrhagic Stroke:** Minimum wait period of 21 days from stroke onset.
- **Subarachnoid Hemorrhage:** Minimum wait period of 21-28 days from onset, with secured aneurysm required before air travel.

These timing guidelines are supported by research from Al-Khindi., *et al*. [13], who found that allowing sufficient time for stabilization after stroke significantly reduced the risk of in-flight complications.

Critical assessment parameters

- **Cerebral Edema:** Presence of cerebral edema is a contraindication to commercial air travel.
- **Hemorrhage Evolution:** Stability for >72 hours is required for consideration of repatriation.
- **Neurological Status:** Stability for >72 hours is required for consideration of air travel.
- **Blood Pressure Control:** Stability within target range for >48 hours is required for consideration of air travel.

CSF leak patients

Timing considerations

- **Post-Traumatic CSF Leak:** Minimum wait period of complete resolution plus 7 days.
- **Post-Surgical CSF Leak:** Minimum wait period of complete resolution plus 10 days.
- **Spontaneous CSF Leak:** Minimum wait period of complete resolution plus 14 days.
- **Absolute Contraindication:** Any active CSF leak.

Critical assessment parameters

- **Leak Resolution Confirmation:** Clinical, laboratory, and imaging confirmation of complete resolution is required.
- **Intracranial Pressure:** Normal intracranial pressure is required for safe air travel.
- **Pneumocephalus:** Presence of pneumocephalus is an absolute contraindication to commercial air travel.

Spinal injury patients

Timing considerations

- **Stable Spinal Fractures (Non-Surgical):** Minimum wait period of 7-10 days from injury with appropriate immobilization.
- **Post-Surgical Spinal Stabilization:** Minimum wait period of 7 days from surgery.
- **Spinal Cord Injury without Fracture/Instability:** Minimum wait period of 7 days from injury with neurological stability.
- **Acute Disc Herniation/Radiculopathy:** Minimum wait period of 3-5 days from onset with pain control.

Critical assessment parameters

- **Spinal Stability:** Confirmed stability is required for safe air travel with appropriate immobilization.
- **Neurological Status:** Stability for >72 hours is required for consideration of air travel.
- **Pain Control:** Well-controlled pain with oral medication is required for air travel.
- **Respiratory Function:** Normal or only mild impairment is required for commercial air travel.

Each condition-specific protocol includes a transport method decision matrix, pre-flight checklist, and documentation requirements tailored to the specific condition and common repatriation destinations from the UAE.

Implementation and practical applications

The standardized assessment framework and condition-specific protocols presented in this paper have several practical applications for neurosurgeons and healthcare providers in the UAE:

Clinical decision support

The framework and protocols provide structured guidance for assessing fitness-to-fly in neurosurgical patients, supporting evidence-based clinical decision-making. By following these guidelines, neurosurgeons can ensure a comprehensive assessment that considers all relevant factors.

Standardization of practice

Implementation of these guidelines can help standardize the assessment process across practitioners and healthcare facilities in the UAE. This standardization can improve consistency in decision-making and reduce variability in practice.

Documentation and communication

The structured format of the assessment framework facilitates clear documentation and communication with airlines, receiving facilities, and transport providers. This can help streamline the repatriation process and reduce delays due to incomplete or unclear medical information.

Risk mitigation

By providing detailed guidance on timing considerations, critical assessment parameters, and special considerations for each neurosurgical condition, the protocols help identify and mitigate risks associated with air travel for these patients.

Implementation strategy

To facilitate adoption of these guidelines, we recommend the following implementation steps:

- **Educational Workshops:** Conduct training sessions for neurosurgeons and other healthcare providers involved in repatriation decisions.
- **Electronic Integration:** Incorporate the assessment framework into electronic health record systems.
- **Quality Monitoring:** Establish a feedback mechanism to track outcomes and refine protocols based on clinical experience.
- **Airline Collaboration:** Engage with major airlines serving the UAE to align medical clearance processes.

Limitations and future directions

While the standardized assessment framework and condition-specific protocols presented in this paper address a significant gap in current practice, several limitations and areas for future research should be acknowledged:

Limitations

- **Limited Empirical Validation:** The framework and protocols are based on literature review and expert validation, but have not been empirically validated in a large cohort of neurosurgical patients.
- **Evolving Evidence Base:** The field of aeromedical evacuation is continuously evolving, and new evidence may emerge that necessitates updates to these guidelines.
- **Variability in Airline Policies:** Despite these standardized guidelines, individual airlines may have specific policies that differ from these recommendations.
- **Lack of Quantitative Data:** Limited data exists on the frequency and outcomes of neurosurgical patient repatriations from the UAE, making it difficult to assess the full scope of the problem.
- **COVID-19 Considerations:** The ongoing impact of the COVID-19 pandemic on aeromedical evacuation protocols may require additional considerations not fully addressed in these guidelines.

Future directions

- **Prospective Validation:** Future research should focus on prospectively validating these guidelines in a cohort of neurosurgical patients requiring repatriation from UAE hospitals.
- **Electronic Decision Support:** Development of electronic decision support tools based on these guidelines could facilitate implementation in clinical practice.
- **Airline Collaboration:** Collaboration with major airlines serving the UAE to align their medical clearance forms with these guidelines would enhance standardization.
- **Outcome Registry:** Establishing a registry to track outcomes of neurosurgical patient repatriations would provide valuable data for refining these guidelines.
- **Expansion to Telemedicine:** Exploring the role of telemedicine in post-repatriation follow-up could enhance continuity of care for patients returning to countries with limited neurosurgical resources.

Conclusion

The repatriation of neurosurgical patients from UAE hospitals presents unique challenges due to the physiological effects of air travel, the complexity of neurosurgical conditions, and the diverse destinations to which patients are being repatriated. With approximately 88% of the UAE population being expatriates, the need for standardized, evidence-based protocols for neurosurgical patient repatriation is particularly acute in this region.

The standardized assessment framework and condition-specific protocols presented in this paper address a significant gap in current practice by providing comprehensive guidelines for assessing fitness-to-fly in neurosurgical patients. These protocols encompass five common neurosurgical conditions requiring repatriation: post-operative cases, traumatic brain injury, stroke, cerebrospinal fluid leaks, and spinal injuries. Each protocol provides detailed guidance on timing considerations, critical assessment parameters, and transport method selection tailored to the specific condition.

Implementation of these guidelines offers several significant benefits for clinical practice in the UAE:

- **Enhanced Patient Safety**: By providing evidence-based criteria for assessing fitness-to-fly, these guidelines can help reduce the risk of in-flight complications and ensure that patients are repatriated only when medically appropriate.
- **Standardized Assessment Process**: The structured framework promotes consistency in assessment practices across different practitioners and healthcare facilities, reducing variability in decision-making.
- **Improved Communication**: The standardized documentation format facilitates clear communication with airlines, receiving facilities, and transport providers, potentially reducing delays in the repatriation process.
- **Optimized Resource Utilization**: By providing clear guidance on transport method selection, these protocols can help ensure that appropriate resources are allocated based on patient needs.

- **Reduced Medico-legal Risk**: Following evidence-based protocols for fitness-to-fly assessment can provide legal protection for practitioners in cases where complications arise during repatriation.

The framework and protocols are designed to be practical for clinical implementation while addressing the specific needs of the UAE healthcare context, including common repatriation routes to countries such as India, Pakistan, Bangladesh, Philippines, and other Arab nations. They provide a bridge between general aeromedical guidelines and the specific requirements of neurosurgical patients, filling a critical gap in current practice.

Future research should focus on prospective validation of these guidelines, development of electronic decision support tools, collaboration with airlines, and establishment of outcome registries. Through continued research, collaboration, and refinement, these guidelines can evolve to meet the changing needs of patients and healthcare systems in the UAE and beyond.

Declarations

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- **Conflicts of Interest:** The authors declare no conflicts of interest.
- **Ethics Approval:** This study did not involve human subjects and was exempt from ethics committee approval.

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