How to handle cardiac arrest in spaceflight - a guideline for cardiopulmonary resuscitation in microgravity

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Conflict of interest
Why do we need a special guideline?

European Resuscitation Council Guidelines for Resuscitation 2015
Section 3. Adult advanced life support

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Why do we need a special guideline?
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Microgravity
What is the likelihood of a severe medical event?

- General population: 6% per person per year
  - crew of 6, with mission duration ~ 900 days
  - one severe medical event!

- Life threatening event: 1% per person per year
  - crew of 6, 900 days
  - 15-20% chance

- BUT: Highly screened, (mostly) young and healthy population

- Space tourism: probably also older participants
  - pre-existing conditions
Every severe medical event could lead to a cardiac arrest
→ We need a plan
Every severe medical event could lead to a cardiac arrest
→ We need a plan
• Up to this day → no cardiac arrest in microgravity
  → No CPR, no experience under real conditions

• Only 3 instances ever required evacuation (1x urosepsis, 1x 14-beat run VT, 1 x severe headache after possible CO² buildup)

• Evacuation is at the moment only possible via Sojuz spacecraft
• → Necessity to wear pressurized suit

• For space exploration missions → no prompt evacuation will be possible
• Formation of a taskforce
• Scientists with a wide range of backgrounds
• Aerospace medicine, emergency medicine, anaesthesia, surgery, cardiology, physics,…
Methods

• Brainstorming
• Determination of relevant topics (15 main groups)
  - Chest compressions
  - Automated chest compression devices
  - Airway management
  - Ventilation
  - Suction
  - Defibrilation
  - Vascular access
  - Medication
  - ROSC
  - Death
  - Telemedicine
  - Reversible causes
  - Technical limitations of spaceflight
  - Training
  - Ethics
• Development of 137 PICO-questions to guide the literature research

• “Should a patient in cardiac arrest in microgravity be fastened on the crew medical restraint system for CPR or should he be free floating regarding beginning of effective chest compressions?“

• Search strategy for the MEDLINE® database (www.pubmed.gov)

• “((("restraint, physical"[MeSH Terms] OR restraint[All Fields]) OR "restraint, physical"[MeSH Terms]) OR fasten[All Fields]) AND (((("weightlessness"[MeSH Terms] OR "weightlessness"[All Fields] OR "microgravity"[All Fields]) OR "weightlessness"[MeSH Terms]) OR ("weightlessness"[MeSH Terms] OR "weightlessness"[All Fields]))) OR "space flight"[MeSH Terms]) AND ((("cardiopulmonary resuscitation"[MeSH Terms] OR ("cardiopulmonary"[All Fields] AND "resuscitation"[All Fields]) OR "cardiopulmonary resuscitation"[All Fields] OR "cpr"[All Fields]) OR "cardiopulmonary resuscitation"[MeSH Terms]) OR cardiopulmonary[All Fields]) OR "cardiopulmonary resuscitation"[MeSH Terms]) OR ("resuscitation"[MeSH Terms] OR "resuscitation"[All Fields])) OR "cardiopulmonary resuscitation"[MeSH Terms])"

• **Aim: strictly evidence-based guideline (GRADE-methodology)**
Citations identified in literature research n=4368

Screening of abstracts negative results n= 3936

Citations left after screening n=432

Removal of duplicates N=163

After duplicate removal n=269

Only abstract available, original work not in english, no studies n=184

Full texts studies available N=85
• Remaining literature was then rated using the GRADE-method by two groupmembers

• Every taskforce member was assigned to two of the main topics
• → draft of recommendations for the assigned topic
• Then two-round Delphi-procedure for consensus finding

• Taskforce members could rate the proposed recommendations with agreement/disagreement and give additional comments

• Of the 27 proposed recommendations, 23 recommendations were consented, mainly with strong consensus

• Quality of evidence and consensus were then assessed and
• → strength of recommendation determined
Chest compressions
**Compression rate**

- **Fig. 3.** Average CR in ratio to guideline.

**Compression depth**

- **Fig. 2.** Average CD in ratio to guideline.
<table>
<thead>
<tr>
<th>No.</th>
<th>Recommendations</th>
<th>Quality of evidence (QoE)</th>
<th>Consensus</th>
<th>Strength of recommendation</th>
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<tbody>
<tr>
<td>#1</td>
<td>CPR in microgravity SHOULD be divided into a chain of survival consisting of Basic Life Support (BLS) and Advanced Life Support (ALS).</td>
<td>moderate</td>
<td>strong</td>
<td><strong>1B strong recommendation moderate-quality evidence</strong></td>
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<tr>
<td>#2</td>
<td>For BLS at the site of emergency the Evetts-Russomano method (ER) of performing chest compressions SHOULD be applied. If the rescuer cannot perform adequate chest compressions with the ER method, he should switch to the Reverse-Bear-Hug method (RBH).</td>
<td>moderate</td>
<td>strong</td>
<td><strong>1B strong recommendation moderate-quality evidence</strong></td>
</tr>
<tr>
<td>#3</td>
<td>As soon as the patient has been restrained on the Crew Medical Restraint System chest compressions SHOULD be applied using the Handstand-method (HS).</td>
<td>moderate</td>
<td>strong</td>
<td><strong>1B strong recommendation</strong></td>
</tr>
</tbody>
</table>
Airway management in microgravity: A systematic review

Tobias Warnecke¹ | Felix Tochtermann² | Steffen Kerkhoff³,⁴,⁵ |
Matthieu Komorowski⁵,⁶ | Christopher Neuhaus⁴,⁷ | Jochen Hinkelbein³,⁴,⁵
<table>
<thead>
<tr>
<th></th>
<th>ETT</th>
<th>COPA</th>
<th>LMA</th>
<th>ILM</th>
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<td>Restraints</td>
<td>Poolside</td>
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<td>Insertion attempts; n</td>
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<tr>
<td>1</td>
<td>40</td>
<td>0</td>
<td>22</td>
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<td>Placement; n</td>
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<tr>
<td>Adequate</td>
<td>40</td>
<td>6</td>
<td>37</td>
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<tr>
<td>Inadequate</td>
<td>0</td>
<td>1*</td>
<td>2*</td>
<td>4</td>
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<tr>
<td>Airway management failure; n</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time to successful insertion; s</td>
<td>19 ± 3</td>
<td>33 ± 21</td>
<td>36 ± 7</td>
<td>19 ± 3</td>
</tr>
</tbody>
</table>

Number of insertion attempts, adequacy of placement, airway management failure and time to successful insertion in normogravity by the poolside (Poolside), simulated microgravity with the manikin floating free (Free-floating) and simulated microgravity with the manikin attached to the floor with restraints (Restraints) for the endotracheal tube (ETT), cuffed oropharyngeal airway (COPA), standard laryngeal mask airway (LMA) and intubating laryngeal mask airway (ILM). Data are mean ± SD or numbers (%).

* Esophageal intubation.
| #10 | The endotracheal intubation remains the gold standard for securing the airway if performed by a skilled provider and SHOULD be executed in that case. | moderate | strong | 1B strong recommendation moderate-quality evidence |
| #11 | When endotracheal intubation is attempted patient and rescuer should be restrained using the Crew Medical Restraint System. | moderate | strong | 1B strong recommendation moderate-quality evidence |
| #12 | If no rescuer with extensive training in endotracheal intubation is present a second generation supraglottic airway device SHOULD be used for airway management. | moderate | strong | 1B strong recommendation moderate-quality evidence |
## Defibrillation

| #15 | A defibrillator SHOULD only be used on a patient that is restrained to an electrically isolated and safe surface. | low | strong | 1C strong recommendation low-quality evidence |
| #16 | An automated external defibrillator (AED), with long duration batteries and long shelf-life self-adhesive pads, SHOULD be stored with the emergency equipment. | low | strong | 1C strong recommendation low-quality evidence |
| #17 | The AED SHOULD have a user-friendly interface, a step-by-step instruction voice for correct pads positioning and electrical shock delivery and a timing device for correct chest compressions/ventilation rate. | low | strong | 1C strong recommendation low-quality evidence |
| #18 | All crewmembers SHOULD be trained in the use of the specific AED provided during the mission. | none | strong | 1C strong recommendation low-quality evidence |
Limitations

- Studies either performed in simulated microgravity or parabolic flight
- → weak representation of the real circumstances during spaceflight
- → parabolic flight offers only ~ 20 seconds of microgravity
- Limited set of studies have been performed
- Case numbers are very low
- → in some cases expert consensus was necessary
Future

• Guideline needs to be reevaluated frequently

• More high quality studies need to be performed

• Possible focus on
  • → defibrillation
  • → crew training
  • → treatment of reversible causes
  • → post resuscitation care
Thank you for your attention!

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List of figures

(2) https://www.zdf.de/kinder/logo/raumfarher-erreichen-iss-100.html
(3) https://www.nasa.gov/johnson/exploration/deep-space
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(7) http://orbitalmedicine.com/