Bewertung des Vertrauens in die Evidenz in Anlehnung an GRADE

Study 1:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Russomano T, Baers JH, Velho R, et al. A comparison between the 2010 and 2005 basic life support guidelines during simulated hypogravity and microgravity. *Extrem Physiol Med*. 2013;2(1):11. doi:10.1186/2046-7648-2-11.	Non-randomized controlled trial	30 male participants	0	Chest compresions using the ER-technique in 0,38 G and µG for 4 cycles according to the 2005 and 2010 ECC guidelines	Chest compressions uaing the ER-technique under 1 G according to the 2005 and 2010 ECC guidelines	Chest compression depth and rate, flexion of elbow, heart rate after chest compression, Ve, VO^2peak, and rate of perceived exertion	No difference in physiologic cost for 2005 and 2010 guidelines, but depth of chest compressions was not sufficient in the intervention group (for the 2005 guideline (28.5 ± 7.0 mm, aim 50 mm max) and 2010 (32.9 ± 8.7 mm, aim at least 50 mm)	
Conclusion: Future intensified training and increased muscle strength of upper extremities for the ER technique as part of BLS training for future space missions is necessary. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Non-serious **Level of Evidence: Moderate*** ***Uprating because of large effect**								

Study 2:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Kordi M, Cardoso RB, Russomano T. A Preliminary Comparison Between Methods of Performing External Chest Compressions During Microgravity Simulation. *Aviat Space Environ Med*. 2011;82(12):1161-1163. doi:10.3357/ASEM.3190.2011.	Non-randomized controlled trial	10 male participants	0	Comparison of HS, ER and RBH chest compression technique during 3 CPR cycles in simulated µG	N/A	Chest compression depth and rate, change in heart rate after compressions, perceived exertion using the BORG scale	HS technique showed best results according to compression rate(124.6 6 15.2 bpm), depth (47.3 6 1.2mm) and exertion, although none of the techniques was able to reach the 50 mm compression depth mark	Only Male participants, 3 CPR cycles is far to short for a realistic scenario
Conclusion: The HS-method showed the best results concerning chest compression rate, depth and level of exertion. It is however dependent on the rescuers size and spatial circumstances and can not be applied in every situation. Limitations: Serious Inconsistency: Serious Indirectness: Serious Imprecision: Non-serious **Level of Evidence: Low**								

Study 3:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Kirkpatrick AW, McKee JL, Tien CH, et al. Abbreviated closure for remote damage control laparotomy in extreme environments: A randomized trial of sutures versus wound clamps comparing terrestrial and weightless conditions. *Am J Surg*. 2017;213(5):862-869. doi:10.1016/j.amjsurg.2017.03.027.	RCT	10 male surgeons, 5 either randomly assigned to WC or SS	40% in the SS group due to motion sickness during parabolic flight	Wound closure via a Wound Clamp (WC) technique performed in 1 G and µ G	Conventional wound closure via standard sutures (SS) performed in 1 G and µ G	Achieved full closure of skin, portion of remaining wound opening	0% of SS technique were able to close the wound in µG, but 60% in the WC group	Performed during parabolic flight, only 20 seconds of µG
Conclusion: Using the WC technique for skin closure seems to be more efficient and faster, especially in µG, than compared to a conventional SS technique. Limitations: Non-Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Non-serious **Level of Evidence: Low**								

Study 4

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Baevsky RM, Bennett BS, Bungo MW, Charles JB, Goldberger AL, Nikulina GA. Adaptive responses of the cardiovascular system to prolonged spaceflight conditions: assessment with Holter monitoring. *J Cardiovasc Diagn Proced*. 1997;14(2):53-57. http://www.ncbi.nlm.nih.gov/pubmed/11539935.	Oberservational study	2 crew membes	0	N/A	Observation of holter ECGs during 175 day mission aboard the MIR station	Assesment of heart rate, occurrence of arrhythmias	Both crew members had significant increase of heart rate, the rise of stress index, the decrease in power of the spectrum in the range of respiratory sinus arrhythmia	
Conclusion: During spaceflight under µ G condition an initial increase in heart rate and stress index could be seen. Limitations: Serious Inconsistency: Serious Indirectness: Very serious Imprecision: Serious **Level of Evidence: Very low**								

Study 5:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Rudland S V., Annus T, Dickinson J, Langdon S. Adrenaline degradation in general practice. *Br J Gen Pract*. 1997;47(425):827-828.	Observational study	100 randomly choosen GPs	35%	N/A	Analysis of stored adrenaline vials in GP bags	Adrenaline activity using reverse phase high-performance liquid chromatography and electrochemical detection.	Mean storage time 6,7 months, mean activity of adrenaline vials was 92.9%, range 100.6-62.6%, 12 (18.5%) of the returned vials had an activity of less than 90%, 33% of vials were expired	No microgravity, small sample size, no direct clinical effect shown
Conclusion: Even under harsh environmental conditions and after the expiration date adrenaline activity seems to be better than expected. Limitations: Serious Inconsistency: Serious Indirectness: Very serious Imprecision: Serious **Level of Evidence: Very low**								

Study 6:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Dutrieue B, Verbanck S, Darquenne C, Prisk GK. Airway closure in microgravity. *Respir Physiol Neurobiol*. 2005;148(1-2 SPEC. ISS.):97-111. doi:10.1016/j.resp.2005.05.015.	Observational Study	9 participants	2 (22%)	Breathing test with test gas composed of 40% SF6, 40% He during µg and hyperG during parabolic flight	Breathing test during 1 G	Inspiratory and expiratory flow rate, gas analysis of SF6 and He	Both He and SF6 phase III slopes were significantly smaller in µG–µG and HG–µG conditions compared to 1G–1G	No direct effect on CPR in microgravity, no relevance for guideline
Conclusion: The measured phase III slope and phase IV height and volume obtained from seven subjects in microgravity were essentially identical irrespective of the gravity level during the pre-test expiration to RV. Limitations: Serious Inconsistency: Non-serious Indirectness: Very serious Imprecision: Serious **Level of Evidence: Very low**								

Study 7:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Keller C, Brimacombe J, A FR, et al. Airway management during spaceflight: A comparison of four airway devices in simulated microgravity. *Anesthesiology*. 2000;92(5):1237-1241. http://133b2da2-5c27-45c9-8290-6952d86f249c/Paper/p1798.	Non-randomized controlled trial	4 male experienced anaesthesiologists	0	Airway management using 4 different devices (ETT,COPA,LMA, ILM) in a submerged scenario, either free-floating or restrained	Airway management using 4 different devices at the poolside in 1 G condition	Number of insertion attempts, failure to insert correctly, adequate or inadequate placement, time to insertion	ETT failed more frequently during the free-floating condition than during the restrained condition (85 vs. 8%, P < 0.001), For the COPA, LMA, and ILM, overall failure was similar among conditions, with a trend towards the LMA	Different manikin for ETT and the LMA settings, effectiveness of ventilation was tested after removal from pool via ventilation
Conclusion: Conventional laryngoscope-guided intubation will have a high failure rate in micro-gravity unless restraints are applied. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Non-serious **Level of Evidence: Low**								

Study 8:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Rabitsch W, Moser D, Inzunza MR, Niedermayr M, Köstler WJ, Staudinger T. Airway management with endotracheal tube versus Combitube (registered trademark) during parabolic flights. Anesthesiology. 2006;105(4):696–702. https://pubs.asahq.org/anesthesiology/article/105/4/696/6740/Airway-Management-with-Endotracheal-Tube-versus.	RCT	4 paramedics	0	Insertion of ETT and Combitube during µG on a manikin in parabolic flight, usage of devices in randomly assigned order and restrained	Insertion of ETT and Combitube during 1G on a manikin on the ground	Time to successful insertion, score of ease	ETC performed equally well between normograv-ity (median, 18 s; range, 17–25 s) and microgravity (median, 18.5 s; range, 17–28 s), ETT performed significantly poorer under microgravity (median, 20 s; range, 17–27 s) as compared with attempts performed under normogravity (median, 18 s; range, 16–22 s) ($P < 0.019$), Differences in success rates between the ETC and ETT were not significant under normogravity or microgravity	Parabolic flight
Conclusion: Time for completion of the insertion procedure and success rates were in favor of the ETC; however, these statistical differences do not necessarily translate into clinical significance. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Non-serious **Level of Evidence: Low**								

Study 9:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Rafiq A, Broderick TJ, Williams DR, Doarn CR, Jones JA, Merrell RC. Assessment of simulated surgical skills in parabolic microgravity. *Aviat Sp Environ Med*. 2005;76(4):385-391.	Non-randomized controlled trial	20 participants (5 female, 15 male), trained surgeons (n=5), non-surgical physicians (n=8), physician astronauts (n=2), non-physician astronauts (n=2), and information technology specialists (n=4)	0	Performance of 4 basic laparoscopic surgical skills (clip applying, cutting, grasping, and suturing) during parabolic in µg	Performance of 4 basic laparoscopic surgical skills (clip applying, cutting, grasping, and suturing) in 1 G	Completion number of tasks, rated via camera by 2 independent surgeons	The number of tasks completed successfully increases during each preflight session with a dramatic decline during microgravity (in flight). On the average participants were able to successfully apply clips on the pre-marked regions in 88% of attempts in preflight (session 5) with the 1-G influence compared with a 44% success rate during flight (session 6+)	Inconsistent participant group (physician/astronauts), Low application of laparoscopic skills to CPR management, parabolic flight
Conclusion: There is a decreased frequency of accurate task completion in parabolic microgravity flight, but it is not an obstacle to implementation of effective training for providing in-flight medical care. Limitations: Serious Inconsistency: Very serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Very low**								

Study 10:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Evetts SN, Evetts LM, Russomano T, Castro JC, Ernsting J. Basic life support in microgravity: Evaluation of a novel method during parabolic flight. *Aviat Sp Environ Med*. 2005;76(5):506-510.	Non-randomized controlled trial	3 participants, trained in regular CPR	1 participate did not perform ventilation	Application of chest compressions and ventilation in the ER technique during µ G in parabolic flight	Application of chest compressions and ventilation in the ER technique during 1 G	Mean VT and mean chest compression depths and rate	Chest Compressions in 1 G and µ G were performed with adequate depth (43.6 +/- 0.59 mm vs. 41.3 +/- 1.03 mm) but with a significantly reduced rate in µG (97.1 +/- 3.0 bpm vs. 80.2 +/- 3.4). Ventilation via mouth-to-mouth ventilation could ne performed with similar VT in 1 G and µ G (507.6 +/- 11.5 ml vs. 491 +/- 50.4 ml)	No Comparison to standard technique or a restrained setup. First test of the ER-Method in parabolic flight.
Conclusion: It is unlikely that perfect BLS can be performed in the absence of gravity. The results of this pilot study suggest that effective single-person CPR in orbital microgravity may be possible irrespective of habitat dimensions and without the aid of specialized equipment. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Non-serious **Level of Evidence: Low**								

Study 11:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Yang TD, Zhang RG, Wang CM, Fu HW, Zhang BL, Zhang JX. Biomedical study on combined effects of simulated weightlessness and emergent depressurization of spacecraft. *Adv Sp Res*. 1999;23(12):2049-2052. http://www.scopus.com/inward/record.url?eid=2-s2.0-0033301633&partnerID=tZOtx3y1.	Observational study	6 male participants	0	ECG under head down bed rest(simulated weightlessness - SW) or hypoxia (at 5000 m altitude pressure) and in combination of SW an hypoxia	ECG in normal upright position under normal ambient air	ECG-changes, especially T-wave mean amplitude were measured.	The T-wave amplitude with 0.14 mv in the condition of hypoxia and SW was significantly smaller than in sitting condition (0.34mv) and SW (0.23mv) or hypoxia (0.21mv) alone.	Only head down bed rest
Conclusion: The present study indicates that SW and hypoxia interact with each other with synergistic effects. A clinical effect cannot be derived from this study. Limitations: Serious Inconsistency: Serious Indirectness: Serious Imprecision: Non-serious **Level of Evidence: Low**								

Study 12:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Hurst VW, Whittam SW, Austin PN, Branson RD, Beck G. Cardiopulmonary resuscitation during spaceflight: Examining the role of timing devices. *Aviat Sp Environ Med*. 2011;82(8):810-813. doi:10.3357/ASEM.2284.2011.	Non-randomized controlled trial	40 participants (23 female, 17 male) without formal medical training except CMO training	0	CPR performed with timing device for chest compressions alone and chest compression and ventilation combined	CPR performed with no timing devices	Number of applied chest compresions and mouth-to-mouth ventilations was counted	None of the analogues delivered the recommended number of breaths (34 6 1 vs. 32) or compressions (258 6 5 vs. 240) without assistance from timing devices.	No focus on correct compression technique, no measurement of depth and pressure release or frequency, No µG simulation, no special techniques for µG
Conclusion: Use of timing devices for chest compressions and ventilation improves adherence to CPR guidelines in minimally trained astronauts Limitations: Serious Inconsistency: Non-serious Indirectness: Non-serious Imprecision: Non-serious **Level of Evidence: Low**								

Study 13:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Johnston SL, Campbell MR, Billica RD, Gilmore SM. Cardiopulmonary resuscitation in microgravity: Efficacy in the swine during parabolic flight. *Aviat Sp Environ Med*. 2004;75(6):546-550.	Non-randomized controlled trial	19 anaesthetized Yorkshire swine (11 in the intervention group and 8 in the control group), 9 different CPR providers	0	11 anaesthetized swine, VF induced by potassium chloride, parabolic flight, either Standard restrained Chest compression or handstand technique + ACLS therapy	8 anaesthetized swine, VF induced by potassium chloride, Standard ACLS therapy	SaO2, PetCO2, mean arterial BP	There was no difference in any of the monitored parameters (SaO2,PetCO2, and mean arterial BP) between the two methods of chest compression, No significant differences in mean PetCO2 readings were noted between CPR performed under 1 G or µ G when compared with the ground (35 +/- 3% v. 33 +/- 3%) or with in-flight (44 +/- 3% v. 41 +/- 3%) pre-arrest PetCO2 values.	In vivo experiment, animal model,
Conclusion: This investigation demonstrated the ability to maintain survivable Pet CO2 values during CPR in 0 G on a porcine animal model The conventional position was quickly fatiguing in microgravity as compared with the unconventional vertical inverted position which required significantly less effort. Limitations: Serious Inconsistency: Non-serious								

Indirectness: Non-serious
Imprecision: Non-serious
Level of Evidence: Moderate

Study 14:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Bungo MW, Johnson PC. Cardiovascular examinations and observations of deconditioning during the space shuttle orbital flight test program. *Aviat Sp Environ Med*. 1983;54(11):1001-1004.	Observational study	8 male participants	0	N/A	Continuous ECG monitoring from before, during and after a spaceshuttle mission, orthostatic provocation tests before and after the flight	Blood pressure and heart rate via ECG were measured and a cardiovascular index of deconditioning (CID) was calculated	The average heart rate for all crewmembers preflight increased with orthostatic provocation by 13 S.D. +/- 6.3 beats/min. Postflight this value was 33.3 S.D. +/- 13.4 beats/min. Yet, the resting supine heart rate postflight was 16.9 S.D. +/- 7,4 beats/min greater than preflight.	No relevance for CPR guideline, except the effects of deconditioning

Conclusion: In summary, the OFT series has provided evidence of cardiovascular deconditioning reflected in changes in heart rate and blood pressure both at rest and in response to orthostatic provocation. Universally, crewmembers react with higher heart rate responses after deconditioning.
Limitations: Non-serious
Inconsistency: Serious
Indirectness: Non-serious
Imprecision: Non-serious
Level of Evidence: Low

Study 15:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Blue RS, Reyes DP, Castleberry TL, Vanderploeg JM. Centrifuge-Simulated Suborbital Spaceflight in Subjects with Cardiac Implanted Devices. *Aerosp Med Hum Perform*. 2015;86(4):410-413. doi:10.3357/AMHP.4122.2015.	Observational study	2 male participants with cardiac implanted devices	0	N/A	Participants underwent seven centrifuge runs over 2 d. Day 1 consisted of two +G z runs (peak 5 +3.5 G z , run 2) and two +G x runs (peak 5 +6.0 G x , run 4). Day 2 consisted of three runs approximating suborbital spacefl ight profi les (combined +G x /+G z).	Blood pressures, electrocardiograms, pulse oximetry, neurovestibular exams, and postrun questionnaires regarding motion sickness, disorientation, greyout, and other symptoms	Neither participant had abnormal physiological responses. Post-spin analysis demonstrated no lead IP: 134.147.5.91 On: Mon, 11 Dec 2017 09:52:00 displacement, damage, or malfunction of either CID.	Only hyper-G, no relevance for µ G CPR, except space tourists with cardiac implanted devices
Conclusion: These cases demonstrate that even individuals with signifi cant medical histories and implanted devices can tolerate the acceleration exposures of commercial spaceflight. Limitations: Serious Inconsistency: Serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 16:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Wotring VE. Chemical Potency and Degradation Products of Medications Stored Over 550 Earth Days at the International Space Station. *AAPS J*. 2016;18(1):210-216. doi:10.1208/s12248-015-9834-5.	Observational study	Nine medications were analyzed	0	N/A	9 FDA-approved medications were returned after 550 days on the ISS	Medications were analyzed using the methods described in the USP to measure the amount of intact active ingredient, identify degradation products when possible, and measure their amounts.	Aspirin samples 9 months beyond the original manufac-turer expiration date contain active ingredient (96.5%), Acetaminophen 97.0%, Ibuprofen (400 mg) 99,9%, only Melatonin (3 mg) showed less than 90 % (89.2%)	No relevant medication for CPR contained
Conclusion: Although it is tempting to conclude from the current results, each based on a single time point, that aspirin, pseudoephedrine, and zolpidem remain safe and effective for more than 6 months after expiration, other studies have made it clear that limited results like these cannot be extrapolated to other time points, brands, or even lots of the same medication. Limitations: Serious Inconsistency: Serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 17:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Wantier M, Estenne M, Verbanck S, Prisk GK, Paiva M. Chest wall mechanics in sustained microgravity. *J Appl Physiol*. 1998;84:2060-2065.	Observational study	Five astronauts were studied before, during, and after the 10-day Spacelab D-2 mission (n =3) and the 180-day Euromir-95 mission (n =2)	0	N/A	Examination before, during and after the mission	Flow and pressure at the mouth and rib cage and abdominal volumes during resting breathing and during a relaxation maneuver from midinspiratory capacity to functional residual capacity	Values of Vab/(Vab +Vrc) recorded in the two subjects on postflight day 1 (31 and 40% for subjects M1 and M2, respectively) were significantly greater than those recorded both preflight and on subsequent postflight days (on average: 21 and 23% for subjects M1 and M2, respectively).	No relevance for CPR in microgravity as artificial ventilation will be provided
Conclusion: It was found that prolonged exposure to microgravity also increased the abdominal contribution to tidal volume and decreased the slope of the relaxation curve on the Konno-Mead plot. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 18:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Martin DS, South DA, Wood ML, Bungo MW, Meck J V. Comparison of echocardiographic changes after short- and long-duration spaceflight. *Aviat Sp Environ Med*. 2002;73(6):532-536.	Observational study	short-duration (n = 13) and long-duration (n = 4) spaceflight crewmembers	0	N/A	Pre- and postflight echocardiographic examination	Echocardiographic measurements (M-mode, 2-D, and Doppler), Ejection fraction was calculated as (LV end diastolic volume - LV end systolic volume)/LV end diastolic vol- ume • 100. Mass was calculated as 1.04 [(diastolic interventricular septal thickness + diastolic LV posterior wall thickness + LV diastolic diameter)	In contrast to short-duration crewmembers, who had a decrease in LV systolic volume and an increase in EF, long-duration crewmembers showed an increase in LV systolic vol- ume and a corresponding decrease in EF	Low relevance for CPR guideline, except cardial deconditioning as a possible predisposition for cardiac arrest
Conclusion: The most interesting findings of the study were the greater long-duration reductions in EF, SV, CO, and an increase in LV systolic volume when compared with short-duration spaceflight. These findings suggest greater cardiac deconditioning and perhaps real changes in cardiac function with long-duration than with short-duration spaceflight. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious								

Imprecision: Serious **Level of Evidence: Low**

Study 19:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Jay GD, Lee P, Goldsmith H, Battat J, Maurer J, Suner S. CPR Effectiveness in Microgravity: Comparison of Three Positions and a Mechanical Device. *Aviat Sp Environ Med*. 2003;74(11):1183-1189.	Non-randomized controlled trial	8 participants performed CPR on a preintubated mannequin over 120 parabolas	0	Chest compression were performed using the Handstand, side straddle and waist straddle technique. Also a mechanical device was tested	N/A	Airway pressure and chest compression depth and rate were measured during CPR	Overall, HS, STD, and SM type CPR positions produced 1.58 in +/- 0.20 in (4.01 cm +/- 0.51 cm), 0.78 in +/- 0.44 in (1.98 cm +/- 1.12 cm), and 1.21 in +/- 0.47 in (3.07 cm +/- 1.19 cm) of compression, respectively, across rescuers with heights of 164–174 cm. The depth of compression for the RBH position was 1.45 in +/- 0.25 in (3.68 cm +/- 0.64 cm) Compressions per minute (cpm) for HS, STD, SS, and RBH during the 5 delivered compressions prior to each ventilation were 98.3 +/- 6.3, 100.0 +/- 3.0, 102.6 +/- 12.1, and 89.3 +/- 4.1 cpm, respectively. A difference existed between the RBH and the HS, STD, and SM positions.	Another shorter rescuer (151.9 cm) was unable to perform compressions in the HS position as he was unable to plant his feet against the "ceiling" while reaching the mannequin's chest. First application of RBH
Conclusion: Two-rescuer CPR in microgravity is most reliably performed in the HS position. Limitations: Serious Inconsistency: Non-serious								

Indirectness: Serious
Imprecision: Serious
Level of Evidence: Moderate

Study 20:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Kirkpatrick AW, McKee JL, Tien H, et al. Damage control surgery in weightlessness. *J Trauma Acute Care Surg*. 2017;82(2):392-399. doi:10.1097/TA.0000000000001310.	Non-randomized controlled trial	10 male surgeons	0	Remote damage control resuscitation using a high-fidelity surgical simulator with a liver laceration afterwards in µ G during parabolic flight	Remote damage control resuscitation using a high-fidelity surgical simulator with a liver laceration first in 1 G	Measured blood loss, number of packs inserted	Although there was less overall "blood" loss during damage control laparotomy in 0g compared to 1g, this did not reach statistical significance in either uncorrected (421.1 mL vs. 341.7 mL; p = 0.161) or corrected analyses (428.1 mL vs. 345.9 mL; p = 0.161) Finally, although surgeons used a similar number of parabolas (mean 1.9 in both 1g and 0g), they were able to place at least as many packs in the course of the laparotomy in 0g as compared to 1g (11.3 vs.10; p =0.402)	No direct relevance for CPR in microgravity, except traumatic arrest
Conclusion: In conclusion, performing RDCR laparotomies with packing of a simulated NCTH exsanguination in a high-fidelity surgical phantom was feasible onboard a research aircraft in both normal and weightless conditions. Despite being subjectively "harder" most phases of operative intervention were rated equivalently, and there was no statistical difference in "blood" loss in weightlessness. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious								

Imprecision: Serious **Level of Evidence: Low**

Study 21:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Mulvagh SL, Charles JB, Riddle JM, Rehbein TL, Bungo MW. Echocardiographic evaluation of the cardiovascular effects of short-duration spaceflight. *J Clin Pharmacol*. 1991;31(10):1024-1026. http://www.ncbi.nlm.nih.gov/pubmed/1761712	Observational study	24 astronauts undergoing short-duration spaceflight		N/A	Evaluation before and after the flight in standing and supine position	Echocardiographic evaluation, RR, HF, EKG,	On landing day the overall heart rate was increased by 23/35% (supine/standing), no significant difference in blood pressure was seen, the supine left-ventricular end-diastolic volume decreased by 11%, and returned to preflight values within 48h, Ejection fraction and velocity of circumferential fibre did not differ	
Conclusion: In summary, echocardiography has provided a useful means to evaluate alterations in cardiovascular physiology after spaceflight. Adaptive responses and countermeasure interventions acquire increasing importance with longer duration exposures to microgravity. Limitations: Serious Inconsistency: Non-serious Indirectness: Non-serious Imprecision: Non-serious **Level of Evidence: Low**								

Study 22:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Bungo MW, Goldwater DJ, Popp RL, Sandler H. Echocardiographic evaluation of space shuttle crewmembers. *J Appl Physiol*. 1987;62(1):278-283. doi:3558187.	Observational study	17 male astronauts	0	N/A	Parameters were evaluated preflight, directly postflight and 2 weeks postflight	Heart rate, RR, echocardiographic measurements, End-diastolic volume index (EDVI), stroke volume index (SVI	Postflight there was an increase in heart rate (HR) (16 beats/ min, 30.5%, $P < 0.05$), mean arterial pressure (12%, $P < 0.05$). End-diastolic volume index (EDVI) fell 17 ml/m² (-23%, $P < 0.005$) and stroke volume index (SVI) fell 15 ml/m² (-28%, $P < 0.05$). Repeat measurements Taken 2 weeks later (n = 17) demonstrated that HR had returned to normal (4 beats/min, $P < 0.05$); however, EDVI remained significantly below preflight levels (-11%, $P < 0.005$). End-systolic volume index (ESVI) was also still significantly lower (-23%, $P < 0.01$).	
Conclusion: These results indicate that spaceflight induces significant changes in heart volume affecting left ventricular function. The exact reasons for these specific changes remain unknown and will require additional measurements before, during, and after flight. Limitations: Serious Inconsistency: Non-serious Indirectness: Non-serious Imprecision: Non-serious **Level of Evidence: Low**								

Study 23:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Darquenne C, Paiva M, Prisk GK. Effect of gravity on aerosol dispersion and deposition in the human lung after periods of breath holding. *J Appl Physiol*. 2000;89(5):1787-1792.	Non-randomized controlled trial	4 participants (2 male/2 female	0	After the subject exhaled to residual volume (RV) they inhaled a predefined aerosol in µ G during parabolic flight. The exhaled air was analyzed	After the subject exhaled to residual volume (RV) they inhaled a predefined aerosol in 1 G, the exhaled air was analyzed	measurements of aerosol concentration and flow rate provided by a photometer in exspiration	At Vp = 150 ml, dispersion was similar at both gravity levels and increased with breath hold time. At Vp =500 ml, dispersion in 1G was always significantly higher than in µ G.	No relevance for CPR in microgravity, no aerosol medications for CPR atm
Conclusion: The data provide direct evidence that gravitational sedimentation is the main mechanism of deposition and dispersion during breath holds. The data also suggest that cardiogenic mixing and turbulent mixing contribute to deposition and dispersion at shallow Vp. Limitations: Very Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 24:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Vallbona C, Dietlein LF, Judy W V. Effect of orbital flight on the duration of the cardiac cycle and of its phases. *Aerosp Med*. 1970;41(5):529-537.	Observational study	6 male astronauts	0	N/A	Continuous measurement of the parameters	ECG and phonocardio-graphic measurements before during and after short duration spaceflight	All the astronauts had marked acceleration of the heart rate (i.e. short cardiac cycle) during lift-off, there was rapid deceleration as soon as the spacecraft entered into orbit (approximately 7 minutes from lift-off). A few extrasystoles were detected in all the astronauts at some times in the mission. In general, they were detected at lift-off or re-entry, but the incidence was too small to be considered of any significance.	No relevance for CPR guideline
Conclusion: The results of this study showed the fluctuations of the time of systole and of the interval between the first and second heart sounds correlated with the total duration of the cardiac cycle, while the electromechanical delay (Q to first heart sound) remained fairly constant. Significantly shorter values of electromechanical delay, however, were observed at the times of lift-off and re-entry when the heart rates were high. Limitations: Non-serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 25:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Hyatt KH, Johnson PC, Hoffler GW, et al. Effect of potassium depletion in normal males: an Apollo 15 simulation. *Aviat Sp Environ Med*. 1975;46(1):11-15.	Observational study	2 male participants	0	N/A	Participants were trained and observed like future astronauts and received the same nutrition as during a mission in bedrest simulation	Potassium levels, sweat production, ECG, appearance of arrhythmias, also during exercise testing	Both were in negative potassium balance throughout bedrest, although to a greater degree during the first week. One participant showed prominent U waves and nonspecific T-wave changes at lower K+-levels,	Primarily a nutrition study. Possible effect for CPR guideline could be the reason for a reversible cause of cardiac arrest - hypokalemia
Conclusion: This study points up the need for more detailed studies of the effect of manned space flight on potassium metabolism. Limitations: Very serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 26:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
D'Aunno DS, Dougherty AH, DeBlock HF, Meck J V. Effect of short- and long-duration spaceflight on QTc intervals in healthy astronauts. *Am J Cardiol*. 2003;91(4):494-497. doi:10.1016/S0002-9149(02)03259-9.	Observational study	7 astronauts, 6 male, 1 female	0	N/A	Retrospective analysis of recorded ECG before, during and after spaceflight	PR, RR, and QT intervals were measured, arrhythmias were searched, serum concentrations for potassium, calcium, and magnesium were analyzed before and after flight	After a long-duration flight, 24% of the QTc intervals were >0.45 second. After a short-duration flight, QTc intervals were not prolonged.	Possible reversible cause, QT elongation
Conclusion: The major finding of this study is that long-, but not short-, duration spaceflight prolongs cardiac conduction and repolarization. Shifts in sympathovagal balance and primary cardiac changes may be responsible. Long-duration flight is associated with QTc interval prolongation and may increase arrhythmia susceptibility. Limitations: Very serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 27:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Ray C a, Vasques M, Miller T a, Wilkerson MK, Delp MD. Effect of short-term microgravity and long-term hindlimb unloading on rat cardiac mass and function. *J Appl Physiol*. 2001;91(3):1207-1213. http://www.ncbi.nlm.nih.gov/pubmed/11509517.	Non-randomized controlled trial	Hindlimb-unloaded group: 49 Sprague-Dawley Rats (20 control group, 10 7-day hindlimb-unloaded, 19 28-day hindlimb-unloaded) Spaceflight group 32: (12 preflight, 7 real flight, 6 cage simulation, 7 vivarum control)	0	Either Hindlimb-unloaded µG simulation, or real spaceflight	Dissection of normal rats	The rats were decapitated after the specific test setting, and the heart was excised, dissected into the right and left ventricle and septum, and weighed. Finally, the soleus muscle was dissected from the hindlimb and weighed.	Heart mass was unchanged in adult animals exposed to 7 days of actual microgravity (PF 1.33 +/- 0.03 g; Fl 1.32 +/- 0.02 g; Sim 1.28 +/- 0.04 g; Viv 1.35 +/- 0.04 g). Similarly, heart mass was unaltered with hindlimb unloading (Con 1.40 +/- 0.04 g; 7HU 1.35 +/- 0.06 g; 28HU 1.42 +/- 0.03 g). Hindlimb unloading also had no effect on the peak rate of rise in left ventricular pressure, an estimate of myocardial contractility (Con 8,055 +/- 385 mmHg/s; 28HU 8,545 +/- 755 mmHg/s).	Only animal study, transferability unclear
Conclusion: These data suggest that cardiac atrophy does not occur after short-term exposure to microgravity and that neither short- nor long-term simulated microgravity alters cardiac mass or function. Limitations: Very serious Inconsistency: Non-serious Indirectness: Serious								

Imprecision: Serious **Level of Evidence: Low**

Study 28:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Dai K, Wang Y, Yan R, et al. Effects of microgravity and hypergravity on platelet functions. *Thromb Haemost*. 2009;101(5):902-910. doi:10.1160/TH08-11-0750.	Non-randomized controlled trial	23 mal mice	0	Male mice exposed to simulated microgravity and hyper G	Exposure to normal 1 G	Tail bleeding test, analysis of platelet function	The tail bleeding time of mice subjected to tail suspension-hind limb unloading was assayed. Interestingly, the median tail bleeding time of hindlimb unloaded mice was significantly longer than that of synchronous 1 G controls (p=0.03)	Animal study, no relevance for CPR guideline
Conclusion: The data described in this study indicate that the platelet functions are inhibited in microgravity environments and activated under high-G conditions. Limitations: Very serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 29

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Kumar K V., Waligora JM, Powell MR. Epidemiology of decompression sickness under simulated space extravehicular activities. *Aviat Sp Environ Med*. 1993;64(11):1032-1039.	Observational study	164 healthy subjects participated in 426 exposures to altitude	0	N/A	22 different pressure profiles involving single and staged decompression procedures, each lasting from 180 to 360 min at the final altitude	Appearance of DCS symptoms, precordial doppler registration of microbubbles	Symptoms of DCS occurred in 17% (74/426) and circulating microbubbles by precordial Doppler ultrasound were detected in 42% (179/426) of all exposures. About 27% (20/74) of exposures with symptoms resulted in test abort, and one-third of all test aborts required treatment in the hyperbaric chamber.	
Conclusion: These findings emphasize the importance of evaluating risk fac- tors from ground-based trials for application in operational de- cision-making and treatment strategies. Limitations: Very serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 30:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Gillis DB, Hamilton DR. Estimating outcomes of astronauts with myocardial infarction in exploration class space missions. *Aviat Sp Environ Med*. 2012;83(2):79-91. doi:10.3357/ASEM.2404.2012.	Retrospective Observational study	"astronaut-like" cohorts were derived from two prospective trials identified by an evidence-based literature review, population of 10,746 persons	N/A	N/A	Registry analysis	Analysis for type of MI, cardiac arrest, prevalent heart-rhythms, outcome defined by death/	Low AMI likelihoods are estimated in individuals with CAC scores of zero or <100 and a low number of FRF. Survival rate to hospital discharge after out of hospital SCA in a large urban environment study was 5.2%. EMS-witnessed ventricular tachycardia and/or ventricular fibrillation survival rate of 37.5% represents <1% off all cases.	Only registry data of urban EMS system, differences in earth based OHCA
Conclusion: Multiple factors may be expected to delay or defeat rapid access to "chain of survival" resources during LDSM, lowering survival rates below urban levels of 5.2%. Low CAC and FRF reflect lower risk for AMI events. Limitations: Very serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 31:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Rehnberg L, Russomano T, Falcao F, Campos F, Everts SN. Evaluation of a novel basic life support method in simulated microgravity. *Aviat Space Environ Med*. 2011; 82(2):104-110. doi:10.3357/ASEM.2856.2011.	Non-randomized controlled trial	21 male subjects	0	Chest compressions/ventilation in simulated µ G in a Body Suspension Device (BDS) for 3 min at 30:2 ratio	Chest compressions/ventilation in 1 G applying the conventional earth-based technique for 3 min at 30:2 ratio	Chest compression rate and depth, elbow flexion measurement, heart rate via ECG, exertion with BORG-scale	Rate of chest compression was maintained at 100 compression/min in both sessions and over the 3-min protocol. Significant decreases in depth of chest compression were seen throughout the 3 min when using the ER method in simulated microgravity; however, the values obtained still fell within AHA guidelines (minute 1: 45.7 +/- 2.44 mm, ts = 0.37, P = 0.003; minute 2: 43.0 +/- 5.23 mm, ts = 0.50, P < 0.001; and minute 3: 41.4 +/- 5.77 mm, ts = 0.53, P < 0.001).	First application of ER technique in BSD
Conclusion: The results of this study suggest that the ER method may be an effective single-person CPR method over 3 min. Although depth of chest compression decreased in simulated microgravity, compared to terrestrial CPR, the results still suggest that the ER method is clinically relevant according to AHA guidelines. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 32

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Rossum AC, Wood ML, Bishop SL, Deblock H, Charles JB. Evaluation of cardiac rhythm disturbances during extravehicular activity. *Am J Cardiol*. 1997;79(8):1153-1155. doi:10.1016/S0002-9149(97)00071-4.	Observational study	7 astronauts (1 female, 6 male)	0	N/A	analysis of pre-, in- and postflight ECGs	Evaluation for PR and QRS duration, ST-segment and T-wave changes, ectopic beats, and rhythm disturbances	Sinus rhythm was recorded in all subjects during each phase of the study. No episodes of junctional, ventricular, or atrial tachyarrhythmias were present. Isolated episodes of phasic sinus arrhythmias were noted in 71% (n = 5) of the sample. The largest recorded RR interval was 2.5 seconds.	
Conclusion: The present study represents the first systematic evaluation of dysrhythmias and cardiac response during EVA. Although limited by sample size, the data suggest that the incidence of dysrhythmias in this sample group are no greater during EVA than any other phase of a mission and that EVA does not precipitate deleterious cardiac events during space flight. Limitations: Serious Inconsistency: Non-serious Indirectness: Non-Serious Imprecision: Serious **Level of Evidence: Low**								

Study 33:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Dalmarco G, Colder A, Falcão F, et al. Evaluation of external cardiac massage performance during hypogravity simulation. *Annu Int Conf IEEE Eng Med Biol - Proc*. 2006:2904-2907. doi:10.1109/IEMBS.2006.259444.	Non-randomized controlled trial	20 participants (10 male, 10 female)	0	Chest compressions in standard side position for 3 min hypogravity simulation: 0.17G (Lunar gravity), 0.38G (Mars gravity) and 0.7G (´Planet X´)	Chest compressions in standard side position for 3 min in 1 G	Measurement of external chest compression depth and rate, angle of elbow flexion	The rate of chest compressions was not different between 1G and hypogravity in the male group. However, there was a trend towards chest compression rate being slower in the female group in hypogravity as compared with 1G. Similarly, male subjects maintained an adequate chest compression depth in the three hypogravity environments. Depth of compression, however, was inadequate in the female group during Lunar and Martian gravitational environments as compared to 1G.	Only hypogravity, no microgravity, only standard position
Conclusion: The results of this study of terrestrial CPR in hypogravity suggest that these conditions lead to an alteration of the manner in which the terrestrial method of external chest compression is performed. It appears that the rescuer arm and shoulder muscular effort by means of greater elbow flexion and extension is increased to counter the decrease in body weight. Limitations: Non-Serious Inconsistency: Non-serious Indirectness: Non-Serious Imprecision: Serious **Level of Evidence: Moderate**								

Study 34

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Du B, Daniels VR, Vaksman Z, Boyd JL, Crady C, Putcha L. Evaluation of Physical and Chemical Changes in Pharmaceuticals Flown on Space Missions. *AAPS J.* 2011;13(2):299-308. doi:10.1208/s12248-011-9270-0	Non-randomized controlled trial	35 medications that are part of the medical ISS kit	0	Identical medication that was stored on the ISS for 13 days, 1 year, 1 ½ year, and 28 months	Identical medication stored in a controlled environment on earth	Active pharmaceutical content (API) was determined by ultra- and high-performance liquid chromatography after returning to Earth	No changes in physical appearance were observed in ground control samples of formulations from payloads 1–3 while physical changes in some of the solid and semisolid formulations after flight were observed with samples from all the four payloads. An interesting observation is that the number of formulations with physical changes was higher in flight samples from all payloads than in controls but variable between payloads. After 880 days of storage in flight (payload 4), only 27% of solid formulations met the acceptance criteria for content.	Mostly solid medications, although injectable epinephrin is mentioned in the setup its results are not mentioned!
Conclusion: Results from this preliminary investigation designed to examine changes in chemical content and physical attributes of dosage forms stored aboard space missions suggest that there may be differences with respect to potency and rate of degradation of formulations stored in space compared to those on the ground. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Non-serious **Level of Evidence: Moderate**								

Study 35:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
BANCROFT RW, DUNN JE. EXPERIMENTAL ANIMAL DECOMPRESSIONS TO A NEAR VACUUM ENVIRONMENT. *Aerosp Med*. 1965;36:720-725. http://www.ncbi.nlm.nih.gov/pubmed/14334706.	Non-randomized controlled trial	126 dogs	0	Decompression from 180 mmHg to 1-2 mmHg in 1 or 0,2 seconds for a duration of 3-5, 10, 30, 60, 90, 120, 135, 150, 165,180 seconds, 6 dogs per timeframe	No decompr-ession at all	Times for the onset of unconsciousness, survival, recovery, and nonsurvivability were estimated from the effects on the 6 animals for each exposure time and for each variation in the experimental conditions-	All animals exposed to the low pressure for longer than 5 seconds tended to lose consciousness and began to swell and collapse within 9 to 11 seconds. All dogs exposed to the near-vacuum environment for less than 120 seconds survived with essentially uneventful recoveries despite evidence of severe but transitory lung involvement. Exposure times ranging from 120 to 180 seconds resulted in mortality rates of about 15% to more than 80%.	Animal study, Cruel design, would not be possible by 21st Century standards
Conclusion: From these observations on dogs concerning survivability and recovery indicate that the prevention of death by rescue and repressurization with oxygen within the order of 90 seconds appears to be feasible. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Non-serious **Level of Evidence: Moderate**								

Study 36:

Reference	Study design	Participants	Drop out rate	Inter vention	Control	Primary endpoint	Main result	Comment
Dzik WH, Beckman N, Murphy MF, et al. Factors affecting red blood cell storage age at the time of transfusion. *Transfusion*. 2013;53(12):3110-3119. doi:10.1111/trf.12171	Observational study	11 hospitals, 3 blood centers	0	N/A	Surveys of the participating facilities concerning their blood management	Number of beds, type of facility, distance from the supplying blood center, and time taken for routine deliveries to arrive; local policy for RBC shelf life, mean number of crossmatches per RBC, mean time between crossmatch and issue, mean number of RBCs issued per day, number of routine deliveries each week, number of ad hoc deliveries each day, and whether the hospital receives RBC from other depots; policies for crossmatch by age of RBCs, discard by age of RBCs, the mean number of units issued each day, target levels of inventory	Hospitals ranged in size from 341 to 902 beds and maintained daily total RBC inventories that ranged from 167 to 767 units. At Hospital I in our survey, the percentages of RBCs among each ABO and Rh group that expired in 2012 were as follows: O+, 0.1%; O–, 0.2%; A+, 0.1%; A–, 0.3%; B+, 0.1%; B–, 0.7%; AB+, 6.6%; and AB–, 5.4%	No relevance for CPR in microgravity!
Conclusion: In summary, we provide a general approach for estimating the minimum mean age of RBCs at the time of issue to the patient. Limitations: Very serious Inconsistency: Non-serious Indirectness: Very serious								

Imprecision: Non-serious **Level of Evidence: Low**

Study 37:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Kordi M, Kluge N, Kloeckner M, Russomano T. Gender influence on the performance of chest compressions in simulated hypogravity and microgravity. *Aviat Sp Environ Med*. 2012;83(7): 643-648. doi:10.3357/ ASEM.3171.2012.	Randomized, controlled trial	32 participants, 20 male, 12 female	0	Application of chest compressions in the ER technique in 0.16 G (lunar), or 0.35 G (Martian) and 0 G (microgravity)	Application of chest compressions in the ER technique in 1 G	Chest compression depth and rate	No significant difference was observed between male and female mean depth of ECCs at 1 G z (P = 0.487) and 0.35 G z (P = 0.372). During microgravity simulation the mean ECC depth of the female volunteers was lower than the male volunteers (P < 0.0001) and did not achieve the minimum required depth. The frequency of the ECCs was shown to have no significant difference between genders, regardless of the simulated gravitational state.	Metronome and feedback use during the study, ER has disadvantages for women in µG!
Conclusion: In conclusion, this initial evaluation of the performance of ECCs and gender found that the male volunteers were better at performing ECCs during simulated microgravity using the ER method than the female volunteers. However, female volunteers, like the male volunteers, could perform effective ECCs at every simulated gravitational state apart from microgravity simulation. Limitations: Serious								

Inconsistency: Non-serious Indirectness: Very serious Imprecision: Non-serious **Level of Evidence: Moderate**

Study 38:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Baisch F, Beck L, Karemaker JM, Arbeille P, Gaffney FA, Blomqvist CG. Head-down tilt bedrest. HDT'88--an international collaborative effort in integrated systems physiology. *Acta Physiol Scand Suppl*. 1992;604(604):1-12. http://www.ncbi.nlm.nih.gov/pubmed/1509885.	Variety of studies in head-down tilt bedrest	N/A	N/A	N/A	N/A	N/A	N/A	No relevant study within the 13 study supplement identified

Conclusion: N/A
Limitations: Serious
Inconsistency: Serious
Indirectness: Serious
Imprecision: Serious
Level of Evidence: N/A

Study 39:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Gundel A, Drescher J, Spatenko YA, Polyakov V V. Heart period and heart period variability during sleep on the MIR space station. *J Sleep Res*. 1999;8(1):37-43. doi:10.1046/j.1365-2869.1999.00131.x.	Observational study	4 Astronauts aboard MIR station	0	N/A	ECG monitoring before, during and after flight	Recording of sleep polygraphies, EEG, ECG, EMG, temperature, Detection of heart rate, arrhythmias, Recording of sleep polygraphies	The increases in heart period for the four individuals were 66 ms, 123 ms, 67 ms and 144 ms.	Only investigation of sleep and cardiac cycles, no relevance for CPR in microgravity
Conclusion: The analysis of heart period variability in the high frequency (respiratory sinus arrhythmia) band is in congruence with the hypothesis that the decrease of heart rate under microgravity is mainly produced by a marked increase in parasympathetic activity. Limitations: Non-serious Inconsistency: Serious Indirectness: Non-serious Imprecision: Serious **Level of Evidence: Low**								

Study 40:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Jauchem JR, Waligora JM, Taylor GR, Horrigan DJ, Johnson PC. Hematological changes following repetitive decompressions during simulated extravehicular activity. *Int Arch Occup Environ Health*. 1986;58(4):277-285. doi:10.1007/BF00377885.	Non-randomized controlled trial	12 male human subjects	0	Exposure to 6 3-h decompression simulations during simulated EVA	Analysis of pretest status	Occurrence of Venous Gas Emboli in precordial doppler, blood testing of hematological parameters	Following the exposure, significant increases occurred in white blood cell count and activated partial thromboplastin time, and platelet aggregate ratio was significantly decreased Pre-exposure samples from subjects who were susceptible to formation of venous gas emboli (VGE) exhibited a significantly lower degree of ADP-induced platelet aggregation and a significantly higher amount of lymphocyte blastogenic transformation in response to the mitogen phytohemagglutinin than samples from VGE-resistant subjects.	No clinical relevance proven, therefore no relevance for CPR guideline
Conclusion: The results indicate that, following this decompression profile, small but significant changes occur in several hematological parameters, and that levels of certain parameters may be related to susceptibility to VGE formation during decompression. Limitations: Serious Inconsistency: Non-serious								

Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**

Study 41:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Platts SH, Ziegler MG, Waters WW, Meck J V. Hemodynamic effects of midodrine after spaceflight in astronauts without orthostatic hypotension. *Aviat Sp Environ Med*. 2006;77(4):429-433.	Non-randomized controlled trial	5 male astronauts	0	Administration of 10 mg Midodrine orally on landing day	Testing before and after spaceflight without medication intake	Reaction to tilt/stand tests before and after spaceflight, ECG, RR, stroke volume were measured	Systolic pressure (108 +/- 2.87 vs. 119 +/- 3.99 mmHg), diastolic pressure (74.8 +/- 4.55 vs. 80.4 +/- 1.63 mmHg), and cardiac output (2.82 +/- 0.40 vs. 2.45 +/- 0.26 L min-1) during tilt/stand tests were similar between control and midodrine flights, respectively. No subject experienced hypotension or presyncope during any test. Mean postflight upright heart rate was significantly higher than the pre- flight baseline for the control flight (p = 0.001), but was not after the midodrine flight (p = 0.185) compared with their respective preflight upright heart rates.	Medication test, no clinical relevance, as no syncope was noted in both groups, no relevance for CPR in µ G

Conclusion: These data show that midodrine protected against post-spaceflight increases in heart rate without having any adverse hemodynamic effects on non-presyncopal, male astronauts. Among these subjects, midodrine was a safe cardiovascular countermeasure.
Limitations: Serious
Inconsistency: Non-serious
Indirectness: Serious
Imprecision: Serious
Level of Evidence: Low

Study 42:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Evans JM, Ribeiro LC, Moore FB, et al. Hypovolemic men and women regulate blood pressure differently following exposure to artificial gravity. *Eur J Appl Physiol*. 2015;115(12):2631-2640. doi:10.1007/s00421-015-3261-2.	Non-randomized controlled trial	Nine men, eight women	0	Furosemide infusion and 90 min exposure to artificial gravity countermeasure	Furosemide infusion followed by 90 min head-down bedrest	Orthostatic tolerance level examination, ECG, RR	We determined that a single, 90-min exposure to individualized artificial gravity profiles, significantly ($p < 0.033$) increased hypovolemic subjects orthostatic tolerance limit (the time required to produce a presyncopal response to the OTL protocol), compared to their OTL response following 90 min of HDBR. Increase of 30.1 % in men and 22 %in women.	No relevance for CPR in µG, countermeasures for orthostatic dysfunction
Conclusion: A short bout of artificial gravity improved the orthostatic tolerance of hypovolemic men and women and, after further testing, should be considered as a space flight countermeasure that could be applied to astronauts before reentry into a gravity environment. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious								

Level of Evidence: Low

Study 43:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Pantalos GM, Sharp MK, Woodruff SJ, et al. Influence of gravity on cardiac performance. *Ann Biomed Eng*. 1998;26(6):931-943. doi:10.1114/1.30.	Observational study	1 cardiovascular simulator exposed to 80 parabolas of ~ 20 sec µG in parabolic flight	0	N/A	Cardiovascular simulator, that was continuously adapted to the test	Ventricular function data, inflow LVP base, LVP apex, outflow and pressure	The right- ward shift of the ventricular function curves from the inflight and ground-based data is substantial（=3 mm Hg) and results in stroke volume reductions of 20%–50% in the physiologic range.	Only simulator during parabolic flight, low relevance for CPR
Conclusion: The similarity of behavior of the hydraulic model to the human system suggests that the simple physical effects of the lack of hydrostatic pressure may be an important mechanism for the observed changes in cardiac performance in astronauts during the weightlessness of space flight. Limitations: Very serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 44:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Guy HJB, Prisk GK, Elliott AR, Deutschman RA, West JB. Inhomogeneity of Pulmonary Ventilation During Sustained Microgravity as Determined by Single-Breath Washouts. *J Appl Physiol*. 1994;76(4):1719-1729.	Non-Randomized controlled trial	7 astronauts during spaceflight	0	Single-breath nitrogen washouts were performed ,argon was inspired at the start of inspiration, and the inspiratory and expir-atory flow rates were controlled at 0.5 l/s.	Control pre- and postflight standing and supine	Exspiratory evaluation with Mass spectroscopy	Compared with the standing 1-G measurements, there was a marked decrease in ventilatory inhomogeneity during microgravity, as evidenced by the significant reductions in cardiogenic oscillations, slope of phase III, and height of phase IV for nitrogen and argon. However, argon phase IV volume was not reduced, and considerable ventilatory inhomogeneity remained.	No relevance for CPR in microgravity
Conclusion: The presence of a phase IV in microgravity is strong evidence that airway closure still occurs in the absence of gravity. Limitations: Very serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 45:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Peterson LE, Pepper LJ, Hamm PB, Gilbert SL. Longitudinal study of astronaut health: mortality in the years 1959-1991. *Radiat Res*. 1993;133(2):257-264. doi:10.2307/3578364.	Cohort study	195 astronauts	0	N/A	Retrospective registry analysis of astronaut health	Mortality, cancer occurence	There was a total of 20 deaths that occurred during the 32-year follow-up period of which 16 were due to accidents. The all-cause standardized mortality ratio (SMR) was 181 (95% confidence interval 110, 279). There was 1 cancer death in the buccal cavity and pharyngeal ICD-9 rubric whose occurrence was significantly beyond expectation. Mortality for coronary disease was 53% lower than expected (2 deaths; SMR = 47; 95% confidence limits 5, 168). The crude death rate for 12 occupationally related accidents was 445 deaths per 100,000 person-years and was an order of magnitude greater than accidental death rates in the mining industry.	Retrospective analysis
Conclusion: Overall, it was found that astronauts are at a disadvantage as a result of catastrophic accidents. Limitations: Serious Inconsistency: Non-serious								

Indirectness: Non-serious Imprecision: Serious **Level of Evidence: Low**

Study 46:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Respress JL, Gershovich PM, Wang T, et al. Long-term simulated microgravity causes cardiac RyR2 phosphorylation and arrhythmias in mice. *Int J Cardiol*. 2014;176(3): 994-1000. doi:10.1016/j.ijcard.2014.08.138.	Non-randomized controlled trial	34 mice, 15 intervention group, 19 control	0	Exposure to simulated µG through hindlimb unloading for 28-56 days	Equal treatment except no hindlimb unloading	Transthoracic echocardiography, atrial and ventricular intracardiac electrograms (ECGs), analysis of Single ventricular myocytes for calcium	After 28 days of HU, LV- EF was significantly decreased in HU mice (57.5 ± 1.4) compared to baseline (64.9 ± 1.3; P<0.001) and sham (66.7 ± 0.7; P<0.001) (Fig. 3A). After 56 days of HU in a separate group of mice, the LV-EF was decreased further (47.8 ± 1.1) compared with baseline (64.9 ± 1.3; P<0.001) or sham (62.1 ± 1.9; P<0.001).	Animal model, clinical relevance so far not present, possible reversible cause for cardiac arrest
Conclusion: The arrhythmias are likely caused by an increased susceptibility to calcium leak from the sarcoplasmic reticulum. Our study suggests that enhanced activation of CaMKII, which in turn promotes RyR2 phosphorylation at serine 2814. Future strategies to prevent arrhythmias in space flight participants might focus on normalizing intracellular calcium handling or prevention of excessive activation of CaMKII in the heart. Limitations: Serious Inconsistency: Non-serious Indirectness: Very serious Imprecision: Serious								

Level of Evidence: Low

Study 47

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Bason R, Yacavone DW. Loss of cabin pressurization in U.S. Naval aircraft: 1969-90. *Aviat Space Environ Med*. 1992;63(5):341-345. http://www.ncbi.nlm.nih.gov/pubmed/1599378.	Cohort study	Registry data of 205 reported cases of loss of cabin pressure in US naval aircrafts from 1969 to 1990	0	N/A	Registered Cases	Morbidity and Mortality, cause of depressurization	The most common reason for crew-initiated decompression was to clear smoke and fumes from the cockpit/cabin (95%). The most common cause for accidental loss of cabin pressure was mechanical (73.37%), with aircraft structural damage accounting for the remaining 26.63%. Serious physiological problems included 1 pneumothorax, 11 cases of Type I decompression sickness, 23 cases of mild to moderate hypoxia with no loss of consciousness, 18 cases of hypoxia with loss of consciousness, and 3 lost aircraft with 4 fatalities due to incapacitation by hypoxia.	Reporting bias, no spaceflight/ microgravity, potential cause of cardiac arrest
Conclusion: While the incidence of loss of cabin pressure in Naval aircraft appears low, it none-the-less presents a definite risk to the aircrew. Limitations: Serious Inconsistency: Non-serious Indirectness: Very serious Imprecision: Serious **Level of Evidence: Low**								

Study 48:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Rummel JA, Michel EL, Sawin CF, Buderer MC. Medical experiment M-171: results from the second manned Skylab mission. *Aviat Space Environ Med*. 1976;47(10):1056-1060. http://www.ncbi.nlm.nih.gov/pubmed /985276.	Observational study	3 astronauts during skylab 3 mission	0	N/A	Aerobic exercise during the mission of differing intensities on an ergometer	HR,RR	In fact, heart rate during exercise actually decreased for all crewmen in flight. This response indicated improved physical fitness in flight relative to preflight.	Observational data, no relevance for CPR guideline
Conclusion: In summary, data obtained during Skylab 3 demonstrate normal exercise responses during a 59-d exposure to weightlessness. A relatively short postflight readaptation period was required for all crewmen to return to their preflight status. Limitations: Serious Inconsistency: Non-serious Indirectness: Very serious Imprecision: Serious **Level of Evidence: Low**								

Study 49:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Nelson BD, Gardner RM, Ostler D V, Schulz JM, Logan JS. Medical impact analysis for the space station. *Aviat.sp Env Med*. 1990;61(2):169-175. pm:2310363.	Retrospective observational study	Registry data	N/A	N/A	N/A	Morbidity, mortality in astronaut analogue populations (army/navy)	N/A	No relevance for CPR guideline
Conclusion: N/A Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious **Level of Evidence: N/A**								

Study 50:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Migeotte P-F, Prisk GK, Paiva M. Microgravity alters respiratory sinus arrhythmia and short-term heart rate variability in humans. *Am J Physiol - Hear Circ Physiol*. 2003;284(6): H1995-H2006. doi:10.1152/ ajpheart.00409.2002.	Observational study	4 male astronauts	0	N/A	Evaluation before, during, and after 16 days of spaceflight	heart rate (HR), heart rate variability (HRV), and respiratory sinus arrhythmia (RSA)	Early in microgravity, HR was decreased compared with both standing and supine positions and had returned to the supine value by the end of the flight. In microgravity, overall variability, the LF-to-HF ratio, and RSA amplitude and phase were similar to preflight supine values. Immediately postflight, HR increased by 15% and remained elevated 15 days after landing.	Low significance for CPR guideline except cardiovascular deconditioning as cause for cardiac arrest
Conclusion: We believe that our results support the notion that the cardiovascular changes observed after spaceflight are made of a complex interaction between a central autonomic disorder in which cardiorespiratory interactions might be an important contributing factor, differential adaptations of vessels in different anatomic regions, as well as plasma volume reduction and baroreflex alteration. Limitations: Serious Inconsistency: Non-serious Indirectness: Non-serious Imprecision: Serious **Level of Evidence: Low**								

Study 51:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Reynolds RJ, Day SM. Mortality Due to Cardiovascular Disease Among Apollo Lunar Astronauts. *Aerosp Med Hum Perform*. 2017;88(5):492-496. doi:10.3357/AMHP.4757.2017.	Retrospective cohort study	310 astronauts in total	0	Astronauts, that have been exposed to actual spaceflight (lunar, LEO)	Non-flying astronauts, that did not perform a spaceflight	All-cause mortality, especially Cardiovascular disease	Lunar astronauts were significantly older at cohort entry than other astronaut group and lunar astronauts alive as of the end of 2015 were significantly older than nonflight astronauts and LEO astronauts. No significant differences in cardiovascular disease (CVD) mortality rates between astronaut groups was observed, though lunar astronauts were noted to be at significantly lower risk of death by CVD than are members of the U.S. general population (SMR = 13, 95% CI = 3–39)	Retrospective analysis, trend towards no increased cardiovascular risk for astronauts
Conclusion: When age and follow-up time are properly taken into account using cohort-based methods, no significant difference in CVD mortality rates is observed. Care should be taken to select the correct study design, outcome definition, exposure classification, and analysis when answering questions involving rare occupational exposures. Limitations: Non-serious Inconsistency: Non-serious Indirectness: Non-serious Imprecision: Serious **Level of Evidence: Low**								

Study 52:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Scheuring RA, Mathers CH, Jones JA, Wear ML. Musculoskeletal injuries and minor trauma in space: Incidence and injury mechanisms in U.S. astronauts. *Aviat Sp Environ Med*. 2009;80(2) :117-124. doi:10.3357/ ASEM.2270.2009.	Retrospective observational study	219 reported incidents	0	N/A	Database of reported injuries during spaceflight at NASA	Injury, mechanism, location, severity	Incidence over the course of the space program was 0.021 per flight day for men and 0.015 for women. Hand injuries represented the most common location of injuries, with abrasions and small lacerations representing common manifestations of these injuries. Crew activity in the spacecraft cabin such as translating between modules, aerobic and resistive exercise, and injuries caused by the extravehicular activity (EVA) suit components were the leading causes of musculoskeletal injuries.	Retrospective analysis, reporting bias, none of the injuries life threatening
Conclusion: Hand injuries were among the most common events occurring in U.S. astronauts during spaceflight. Identifying the incidence and mechanism of inflight injuries will allow flight surgeons to quantify the amount of medical supplies needed in the design of next-generation spacecraft. Limitations: Serious Inconsistency: Non-serious Indirectness: Non-serious								

Imprecision: Serious **Level of Evidence: Low**

Study 53:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Simons FER, Gu X, Simons KJ. Outdated EpiPen and EpiPen Jr autoinjectors: Past their prime? *J Allergy Clin Immunol*. 2000;105(5):1025-1030. doi:10.1067/mai.2000.106042.	Retrospective Observational study	34 Epi-Pens	0	N/A	Epi-Pens that were carried by patients and were expired by 1-90 months	epinephrine content of the outdated EpiPen and EpiPen Jr autoinjectors was measured by a spec-trophotometric method and an HPLC-UV method	Epinephrine bioavailability from the outdated EpiPen autoinjectors was significantly reduced ($P < .05$) compared with epi- nephrine bioavailability from the in-date autoinjectors.	Small sample size, inconsistent storage time and conditions, no exposure to µG or spaceflight, low significance for guideline
Conclusion: For prehospital treatment of anaphylaxis, we recommend the use of EpiPen and EpiPen Jr autoinjectors that are not outdated. If, however, the only autoinjector available is an outdated one, it could be used as long as no discoloration or precipitates are apparent because the potential benefit of using it is greater than the potential risk of a suboptimal epinephrine dose or of no epinephrine treatment at all. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 54:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Campbell MR, Billica RD, Johnston SL, Muller MS. Performance of advanced trauma life support procedures in microgravity. *Aviat Sp Environ Med*. 2002;73(9):907-912.	Non-randomized controlled study	12 adult anesthetized pigs , 1 non-surgical physician performing the procedures	0	Artificial ventilation, intravenous infusion, laceration closure, tracheostomy, Foley catheter drainage, chest tube insertion, peritoneal lavage, and the use of tele-medicine methods for procedural direction performed during µ G in parabolic flight	Artificial ventilation, intravenous infusion, laceration closure, tracheostomy, Foley catheter drainage, chest tube insertion, peritoneal lavage, and the use of tele- medicine methods for procedural direction performed during 1G on earth	Observation by a skilled surgeon , completion of tasks	Artificial ventilation was performed and appeared to be unaltered from the 1 -G environment. Intravenous infusion, laceration closure, percutaneous dilational tracheostomy, and Foley catheter drainage were achieved without difficulty. Chest tube insertion and drainage were performed with no more difficulty than in the 1-G environment due to the ability to restrain patient, operator and supplies. A Heimlich valve and Sorenson drainage system were both used to provide for chest tube drainage collection with minimal equipment, without the risk of atmospheric contamination, and with the capability to auto-transfuse blood drained from a hemothorax	Only 1 performing physician! First tracheostomy in parabolic flight
Conclusion: The performance of ATLS procedures in microgravity appears to be feasible with the exception of diagnostic peritoneal lavage. Limitations: Serious Inconsistency: Non-serious Indirectness: Very serious Imprecision: Serious								

Level of Evidence: Low

Study 55:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Putcha L, Berens KL, Marshburn TH, Ortega HJ, Billica RD. Pharmaceutical use by U.S. astronauts on Space Shuttle missions. *Aviat Sp Environ Med*. 1999;70(7):705-708.	Retrospective Observational study	79 US space missions, 219 surveyed participants of whom 94% reported medication intake	0	N/A	Astronauts that took some form of medication during spaceflight	Type of medication, route of application, reported side effects	94% included some medication being taken during flight; of that number, 47% were for space motion sickness, 45% for sleep disturbances, and smaller percentages for head- ache, backache, and sinus congestion. Drugs were taken most often orally, followed in decreasing order of frequency by intranasal, intra- muscular, and rectal routes. Drugs for space motion sickness were taken mostly during the first 2 d of flight, drugs for pain during the first 4 d, and drugs for sleeplessness and sinus congestion were taken consistently for 9 flight days. About 85% of all doses had no reported side effects	Retrospective analysis, no ACLS medication studied
Conclusion: Sleep disturbances are becoming the predominant problem for U.S. Shuttle astronauts. Many sleep aids have potentially serious side effects, such as drowsiness, that can persist during wakeful hours; moreover, sustained use of benzodiazepines has been associated with physiological dependence. Space motion sickness remains a significant problem, particularly during the first few days of a mission. Limitations: Serious Inconsistency: Serious Indirectness: Very serious Imprecision: Serious **Level of Evidence: Very low**								

Study 56:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
PUTCHA L, CINTRÓN NM. Pharmacokinetic Consequences of Spaceflight. *Ann N Y Acad Sci*. 1991;618(1 Temporal Cont):615-618. doi:10.1111/ j.1749-6632.1991 .tb27292.x.	Non-randomized controlled trial	12 male astronauts	0	Application of 650 mg Acetaminophen and scopolamine/ Dextramphetamine (0,4/0,5 mg) during spaceflight in µG	Application of 650 mg Acetaminophen and scopolamine/ Dextramphetamine (0,4/0,5 mg) before spaceflight in 1 G	Urinary, blood and saliva samples were taken in prespeciefied schema and analyzed for pharmacological activity	Acetaminophen showed a significant decrease in absorption rate during spaceflight. In all cases maximum saliva concentrations on flight day zero were lower than on the ground.	No ACLS medication tested.
Conclusion: The results support predictions, that drug dynamics change during spaceflight. Specific conclusions can not be drawn from this preliminary study. Limitations: Serious Inconsistency: Serious Indirectness: Very serious Imprecision: Serious **Level of Evidence: Very low**								

Study 57:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Rummell JA, Sawin CF, Buderer MC, Mauldin DG, Michel EL. Physiological response to exercise after space flight--Apollo 14 through Apollo 17. *Aviat Space Environ Med*. 1975 ;46(5):679-683. http://www.ncbi.nlm.nih.gov/pubmed/1131131.	Non-randomized controlled trial	12 male astronauts	0	Prespecified physical exercise regimen performed in µ G during spaceflight	Prespecified physical exercise regimen performed in 1 G on Earth	Vo^2, workload, and systolic blood pressure, heart rate	Tachycardia was evidenced at rest and during exercise immediately postflight. This transitory tachycardia compensated for reduced stroke volume. Systolic blood pressure was reduced during exercise stress, but no consistent changes were observed in diastolic blood pressure. With the exception of the Apollo 15 crewmen, all crewmen had returned to preflight response levels by the day following recovery. No changes were observed in mechanical or respiratory efficiency Immediately postflight.	
Conclusion: Exercise responses measured postflight in the Apollo 14-17 astronauts were generally like those observed during the postflight testing of the Apollo 7-11 astronauts. A common finding was elevated resting and stress heart rates immediately postflight. These generally returned to normal by the day following recovery. Limitations: Serious Inconsistency: Serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 58:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Wu B, Xue Y, Wu P, Gu Z, Wang Y, Jing X. Physiological responses of astronaut candidates to simulated +G x orbital emergency re-entry. *Aviat Sp Environ Med*. 2012;83(8): 758-763. doi:10.3357 /ASEM.3109.2012.	Non-randomized controlled trial	13 male astronaut candidates	0	Exposure to a simulated high 1 G x acceleration profile in a spacecraft during an emergency return lasting for 230 s	Baseline measurements pretest	ECG, HR, SpO^2, Breath rate, Breath amplitude, subjective feelings	Under high 1 G x exposure, 15.4% of subjects exhibited arrhythmia. Heart rate (HR) increased significantly, and four different types of HR response curves were distinguished. SpO^2 reached a minimum (87.7%) at 3 G during the decline phase of the 1 G x curve.	Focus on reentry. No CPR during reentry possible due to seat constraints
Conclusion: Astronaut candidates have relatively good tolerance to the 1 G x profile during a simulation of spacecraft emergent ballistic reentry. However, a few subjects exhibited adverse physiological responses and slight reversible pathological injuries. Limitations: Serious Inconsistency: Serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 59:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Ungs TJ. Population-based description of air and space transport accident mortality, United States, 1979-89. *Aviat Space Environ Med*. 1994;65(3):237-242. http://www.ncbi.nlm.nih.gov/pubmed/8185554.	Retrospective registry analysis	N/A	N/A	N/A	N/A	Morbidity and mortality in spaceflight and regular population	Not applicable for CPR guideline	
Conclusion: N/A Limitations: Serious Inconsistency: Serious Indirectness: Serious Imprecision: Serious **Level of Evidence: N/A**								

Study 60:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Pattarini JM, Blue RS, Castleberry TL, Vanderploeg JM. Preflight screening techniques for centrifuge-simulated suborbital spaceflight. *Aviat Sp Environ Med*. 2014;85(12): 1217-1221. doi:10.3357/ ASEM.4114.2014.	Cohort study	335 subjects who registered for the study, 124 who completed all prescreening, and 86 subjects who participated, groups derived for different chronic deseases	249 (74%)	2 d of centrifuge trials, with maximum acceleration exposures of +6 G x (chest-to-back) and +4.0 G z (head-to-toe), mimicking a suborbital spaceflight profile	Baseline control	ECG and constant video monitoring	Of the subjects approved, four individuals experienced abnormal physiological responses to centrifuge profiles, including one back strain and three with anxiety reactions.	
Conclusion: The screening methods used were judged to be sufficient to identify individuals physically capable of tolerating simulated suborbital flight. Improved methods will be needed to identify susceptibility to anxiety reactions. While severe or uncontrolled disease was excluded, many subjects successfully participated in centrifuge trials despite medical histories of disease that are disqualifying under historical spaceflight screening regimes. Limitations: Serious Inconsistency: Serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 61:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Wu AHB, Gornet TG, Schenkel O, et al. Preliminary evaluation of an experimental clinical chemistry analyzer developed for space medicine. *Clin Chem*. 1993;39(1):37-44.	Observational study	1 experimental clinical chemistry analyzer system	0	N/A	11 standard blood tests were performed on an ICU simultaneously with a conventional clinical chemistry analyzer	Deviation from conventional analyzer	Results for Hb, CK, CK-MB, and glucose obtained with the MDU were less precise than those of the high-volume laboratory-based comparison analyzers. The MDU bias for Ca was unacceptable.	No relevance for CPR in microgravity. Analyzers could have a role in the detection of reversible causes for cardiac arrest.
Conclusion: Our results indicate that the performance of the MDU, an experimental analyzer with limited development history, is adequate for clinical laboratory diagnosis for most of the selected analytes. Although we did not assess absolute accuracy with reference materials and methods, we found that most analyses had good correlation and little bias in comparison with commercial Ektachem analyzer assays of CAP Survey materials. Limitations: Serious Inconsistency: Serious Indirectness: Very serious Imprecision: Serious **Level of Evidence: Very low**								

Study 62:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Alves PM, DeJohn CA, Ricaurte EM, Mills WD. Prognostic Factors for Outcomes of In-Flight Sudden Cardiac Arrest on Commercial Airlines. *Aerosp Med Hum Perform*. 2016;87(10): 862-868. doi:10.3357/AMHP.4479.2016.	Retrospective cohort study	1263 cases, of whom 394 remained after exclusion criteria((1) AED use was for monitoring purposes only; 2) the event occurred on the ground; 3) MedAire was informed postfact; 4) the case was related to transport of a patient with a medical escort; and 5) information was insufficient.)	69%	N/A	Analysis of 10-year period, registered Inflight AED-use	survival-to-hospital and survival-to-discharge the independent variables included shock advised, scheduled minutes remaining to destination, age, gender, diversion status, distance, and whether a physician volunteered	The percentage of RSR cases was 24.6%. The survival to hospital admission was 22.7% (22/97) for passengers in RSR compared with 2.4% (7/297) in the RNSR group. The adjusted odds ratio for survival-to-hospital for the RSR group compared to the RNSR group was 13.6 (5.5–33.5). The model showed odds for survival to hospital decreased with longer scheduled remaining flight duration with adjusted OR 5 0.701 (0.535–0.920) per hour increase. No correlation between diversions and survival for RSR cases was found.	Only commercial flight, no spaceflight!
Conclusion: Survival-to-hospital from IFCAs is best when an RSR is present. The percentage of RSR cases was lower than in other out-of-hospital cardiac arrest (OHCA) settings, which suggests delayed discovery. Flight diversions did not significantly affect resuscitation outcome. Limitations: Serious Inconsistency: Serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 63:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Brunner JX, Westenskow DR, Zelenkov P. Prototype ventilator and alarm algorithm for the NASA space station. J Clin Monit 1989;5:90-99. *J Clin Monit*. 1989;5:90-99.	Non-randomized controlled trial	2 male participants during 260 simulations each	0	Induction of 13 planned malfunctions	Regular use of the ventilator	Overall function, correct answer of the alarm algorithm, determined by expert	The algorithm identified the critical events and generated alarms in response to 99.2% (516 of 520, total) of the events. The alarm textual messages were correct 98% (505 of 516 messages) of the time.	No µ-G testing, only software test
Conclusion: The alarm algorithm is an improvement over current alarms found on most ventilators because its alarm messages specifically iden- tify failures in the patient breathing circuit or ventilator. The system may improve patient care by helping critical care per- sonnel respond more rapidly and correctly to critical events. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 64:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
West JB, Elliott AR, Guy HJ, Prisk GK. Pulmonary function in space. *Jama*. 1997;277(24):1957-1961. http://www.ncbi.nlm.nih.gov/pubmed/9200637%5Cnhttp://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=9200637.	Assortment of different studies and overview article	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Conclusion: N/A Limitations: N/A Inconsistency: N/A Indirectness: N/A Imprecision: N/A **Level of Evidence: N/A**								

Study 65:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Prisk GK, Elliott AR, Guy HJ, Kosonen JM, West JB. Pulmonary gas exchange and its determinants during sustained microgravity on Spacelabs SLS-1 and SLS-2. *J Appl Physiol*. 1995;79(4):1290-1298.	Observational study	8 astronauts (3 female, 5 male) during 9-15 day of µG in spaceflight	0	N/A	Pre-, in- and postflight breath analysis	Analysis of tidal volume, breathing rate, dead space, $etCO^2$	Compared with preflight measurements, µG resulted in a significant reduction in tidal volume (15%) but an increase in respiratory frequency (9%). The increased frequency was caused chiefly by a reduction in expiratory time (10%), with a smaller decrease in inspiratory time (4%).	No relevance for CPR guideline in µ G
Conclusion: The net result was that, although total ventilation fell, alveolar ventilation was unchanged in µG compared with standing in 1 G. Limitations: Serious Inconsistency: Serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 66:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Smith RF, Stanton K, Stoop D, Janusz W, King PH. Quantitative electrocardiography during extended space flight: the second manned skylab mission. *Aviat Sp Environ Med*. 1976;47(4):353-359. doi:10.1016/0094-5765(75)90046-6.	Observational study	3 male astronauts	0	N/A	Continuous ECG monitoring before during and after 59-day SL 3 mission	ECG measurements, HF	A statistically significant increase in QRS maximum vector magnitude (all SL3 crewman); and an increase in resting PR interval (all SL3 crewmen) occurred. During exercise, the PR interval did not differ from preflight. Exercise heart rates in flight were same as preflight, but increased in the immediate postflight period. One astronaut also had intermittent periods of atrioventricular junctional rhythm throughout the flight.	
Conclusion: Ventricular ectopy occurred throughout the three Skylab missions. In general this was sporadic, did not alter hemodynamic function in a detectable manner, and electrocardiographic signs of myocardial ischemia were not associated. Limitations: Serious Inconsistency: Serious Indirectness: Non-serious Imprecision: Serious **Level of Evidence: Low**								

Study 67:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Hasser EM, Moffitt J a. Regulation of sympathetic nervous system function after cardiovascular deconditioning. *Ann N Y Acad Sci*. 2001;940:454-468. http://www.ncbi.nlm.nih.gov/pubmed/11458701.	Overview article!	N/A	N/A	N/A	N/A	N/A	N/A	
Conclusion: N/A Limitations: N/A Inconsistency: N/A Indirectness: N/A Imprecision: N/A **Level of Evidence: N/A**								

Study 68:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Sakowski C, Starc V, Smith SM, Schlegel TT. Sedentary long-duration head-down bed rest and ECG repolarization heterogeneity. *Aviat Sp Environ Med*. 2011;82(4):416-423. doi:10.3357/ASEM.2945.2011.	Non-randomized controlled trial	20 participants (14 male, 6 female)	0	HDBR for 90 days	Pre HDBR as control	ECG+ measurements of plasma volume and electrolytes at 5 points in time: within 10 d before; 28 – 30, 60, and 90 d into; and 3-5 d after HDBR	By repeated measures ANOVA, 90 d of sedentary HDBR significantly increased the QTV index (from - 1.87 +/- 0.33 to - 1.53 +/- 0.39 units), the index of unexplained QTV (from 0.61 +/- 0.48 to 1.21 +/- 0.40 units), the T-wave complexity intradipolar ratio (from 0.344 +/- 0.260 to 2.04 +/- 4.01%), and the spatial QRS-T angle (from 49.1 +/- 23.8 to 58.7 +/- 31.0°), and significantly decreased the spatial ventricular gradient (from 91.3 +/- 26.5 to 59.1 +/- 23.0 mV x ms - 1).	Bedrest study, relevance for actual µG unclear, possible reversible cause
Conclusion: Sedentary, long-duration HDBR reversibly increases ECG repolarization heterogeneity and by inference ventricular arrhythmic risk. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 69:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Arzeno NM, Stenger MB, Lee SMC, Ploutz-Snyder R, Platts SH. Sex differences in blood pressure control during 6 head-down tilt bed rest. *AJP Hear Circ Physiol*. 2013;304(8): H1114-H1123. doi:10.1152/ajpheart.00391.2012.	Non-randomized controlled trial	30 (20 male, 10 female)	By day 60 20%	adrenergic, baroreflex, and autonomic indexes during continuous infusions of vasoactive drugs in men and women during a 60-day head-down bed rest, Three increasing doses of phenylephrine (PE) and sodium nitroprusside were infused for 10 min after an infusion of normal saline	Baseline measurements	RR, HR	Parasympathetic modulation and baroreflex sensitivity decreased with bed rest, with women experiencing a larger decrease in baroreflex sensitivity by day 30 than men. The sympathetic activation of men and parasympathetic responsiveness of women in blood pressure control during physiological stress were preserved throughout bed rest. During PE infusions, women experienced saturation of the R-R interval at high frequency, whereas men did not, revealing a sex difference in the parabolic relationship between high-frequency R-R interval, a measurement of respiratory sinus arrhythmia, and R-R interval.	
Conclusion: Sex differences in blood pressure control during simulated microgravity reveal the need to study sex differences in long-duration spaceflight to ensure the health and safety of the entire astronaut corps. Limitations: Serious Inconsistency: Serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 70:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Grenon SM, Xiao X, Hurwitz S, et al. Simulated microgravity induces microvolt T wave alternans. *Ann Noninvasive Electrocardiol*. 2005;10(3):363-370. doi:10.1111/j.1542-474X.2005.00654.x.	Observational study	24 male participants	0	N/A	9 to 16 days of head-down tilt bed rest (HDTB).	Continuous ECG	Before HDTB, 17% of the subjects were MTWA positive [95%CI: (0.6%, 37%)]; after were MTWA positive after HDTB compared with MTWA negative subjects had an increased versus HDTB, 42% of the subjects were MTWA positive [95%CI: (23%, 63%)] (P = 0.03). The subjects who decreased sympathetic responsiveness (P = 0.03) and serum norepinephrine levels (P = 0.05), and a trend toward higher potassium excretion (P = 0.06) after bed rest compared to baseline.	Clinical relevance unknown, probably low relevance for CPR in µG
Conclusion: HDTB leads to an increase in MTWA, providing the first evidence that simulated microgravity has a measurable effect on electrical repolarization processes. Possible contributing factors include loss in potassium and changes in sympathetic function. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 71:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
McCuaig K, Lloyd CW, Gosbee J, Snyder WW. Simulation of blood flow in microgravity. *Am J Surg*. 1992;164(2):119-123.	Non-randomized controlled trial	1 bleeding simulator	0	Bleeding simulation with whole bovine blood during parabolic flight in µG, 5 parabolas capillary bleeding, 10 venous and 10 arterial	Bleeding simulation with whole bovine blood on earth in 1 G	Function of bleeding control via sponge, absorbent pad and suction	Influenced by surface tension, the slow venous bleeding coated syringe surfaces and formed a dome over the skin laceration bleeding site. Arterial and venous bleeders broke into uniform spheres with low-velocity spheres bouncing off an absorbent pad and suction tip. Conventional dabbing with gauze fragmented blood into small spheres. Capillary oozing was better controlled by "wicking" up blood with gauze. Repeated arterial bleeding opacified the glove box wall.	Proof of Laerdal suction unit function in microgravity, relevant for airway management
Conclusion: The behavior of extracorporeal blood flow in the microgravity environment was strikingly different from that observed on Earth and presents unique problems in hemostatic control. The laerdal suction effectively removed blood from the incision on the pig's foot in a manner similar to that of the terrestrial experience. Limitations: Non-serious Inconsistency: Serious Indirectness: Non-serious Imprecision: Serious **Level of Evidence: Low**								

Study 72:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Navasiolava NM, de Germain V, Levrard T, et al. Skin vascular resistance in the standing position increases significantly after 7days of dry immersion. *Auton Neurosci Basic Clin*. 2011;160(1-2) :64-68. doi:10.1016/ j.autneu.2010. 10.003.	Observational study	8 male participants	0	N/A	Analysis before and after 7 days of simulated microgravity modeled by dry immersion (DI)	Changes of plasma volume and orthostatic tolerance, skin bloodflow, ECG, RR	After DI we observed increased calf skin vascular resistance in the standing position (12.0±1.0 AU—after- vs. 6.8±1.4 AU—before), while supine it was unchanged. Cardiovascular deconditioning was confirmed by greater tachycardia on standing and by hypovolemia (−16±3% at day 7 of DI).	No relevance for CPR guideline
Conclusion: Unchanged autonomic control and total peripheral resistance suggest that increased skin vasoconstriction to standing involves rather local mechanisms – as venoarteriolar reflex – and might compensate insufficient vasoconstriction of other vascular beds. Limitations: Serious Inconsistency: Serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 73:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Hamilton DR, Sargsyan AE, Kirkpatrick AW, et al. Sonographic Detection of Pneumothorax and Hemothorax in Microgravity. *Aviat Sp Environ Med*. 2004;75(3 SEC. I):272-277.	Non-randomized controlled trial	4 pigs, that received intentional hematothroax and pneumothorax	0	Sonographic evaluation during in µ G during parabolic flight	Sonographic evaluation in 1 G on earth	Detection of hematothroax and pneumothorax by sonography	In microgravity, a loss of "lung sliding" was noted simultaneously in the anterior and posterior sonographic windows after 100 ml of air was introduced into the chest, indicating pneumothorax. The presence of the fluid layer in simulated hemothorax was noted in the anterior and posterior sonographic windows after 50 ml of fluid was injected into the pleural space. During the microgravity phase, the intrapleural fluid rapidly redistributed so that it could be detected using either anterior or posterior sonographic windows.	Relevant for detection of reversible cause of cardiac arrest!
Conclusion: Modest to severe pneumothorax and hemothorax can be diagnosed using ultrasound in microgravity. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 74:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Verbanck S, Linnarsson D, Prisk GK, Paiva M. Specific ventilation distribution in microgravity. *J Appl Physiol*. 1996;80(5):1458-65.	Observational study	10 male participants	0	N/A	Rebreathing test before, during and after 10 days of spaceflight	Rate of argon equilibration in the rebreathing bag, termed RB was quan-tified by determining the logarithm of the actual minus the equilibrated argon concentrations normalized to the inspired minus	The comparison between the experimental Earth-based and microgravity RB curves and model simulations shows that gravity-independent V/Vo inhomogeneity is at least as large as gravity-dependent V/Vo inhomogeneity.	No relevance for CPR guideline
Conclusion: Inert gas rebreathing tests performed during the Spacelab D-2 mission and the comparison with simulations based on a simple model of lung ventilation suggest that gravity-independent ventilatory inhomogeneities are at least as large as gravity-dependent ones. Limitations: Serious Inconsistency: Serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 75:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Carr RR, Decarie D, Ensom MHH. Stability of epinephrine at standard concentrations. *Can J Hosp Pharm*. 2014;67(3):197-202.	Non-randomized controlled trial	N/A	0	N/A	N/A	Stability of epinephrin in different solutions at low or normal temperature	N/A	No relevance for CPR guideline, as max. storage time was 30 days and no relation to microgravity or spaceflight
Conclusion: N/A Limitations: N/A Inconsistency: N/A Indirectness: N/A Imprecision: N/A **Level of Evidence: N/A**								

Study 76:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Lyon RC, Taylor JS, Porter DA, Prasanna HR, Hussain AS. Stability profiles of drug products extended beyond labeled expiration dates. *J Pharm Sci*. 2006;95(7): 1549-1560. doi:10.1002 /jps.20636.	Retrospective observation study	Results form the shelf life extension program (SLEP)	N/A	N/A	N/A	N/A	N/A	No microgravity evaluation, no CPR relevant medication
Conclusion: N/A Limitations: N/A Inconsistency: N/A Indirectness: N/A Imprecision: N/A **Level of Evidence: N/A**								

Study 77:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Satava RM. Surgery in space. Phase I: Basic surgical principles in a simulated space environment. *Surgery*. 1988;103(6):633-637. http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=3375989.	Cohort study	20 anesthetized rats underwent surgery by one experienced surgeon	0	N/A	Laparotomy performed in a submerged scenario with neutral buoyancy	Feasibility of a range of surgical procedures	In this limited, acute experiment there were no intraoperative complications. The surgical techniques are inherently identical to those in normal gravity, and the results reflect the difficulty of performing in the new environment, rather than the adequacy of a particular procedure.	Partially submerged scenario
Conclusion: Precise localization in space is different and requires adaptation to readjust the proprioceptors. The recent access to the new environment of weight-lessness in space mandates a reevaluation of basic surgical skills. Initial experience in the simulated space environment with use of neutral buoyancy identifies factors unique to zero gravity that influence the conduct of operative procedures. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 78:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Prisk GK, Elliott a R, West JB. Sustained microgravity reduces the human ventilatory response to hypoxia but not to hypercapnia. *J Appl Physiol*. 2000;88(4):1421-1430.	Observational study	5 participants, 4 male, 1 female	0	N/A	Isocapnic hypoxic ventilatory response and the hypercapnic ventilatory response by using rebreathing techniques before, during, and after 16 days of exposure to microgravity	airflow was measured with a pneumotachograph, gas concentrations were measured with a rapidly responding quadrupole spectrometer	During the hypercapnic ventilatory response test, the ventilation at a PCO2 of 60 Torr was not significantly different in µG (101 +/- 5%) and the supine position (89 +/- 3%) from that measured standing. Inspiratory occlusion pressures agreed with these results.	No relevance for CPR guideline
Conclusion: The findings can be explained by inhibition of the hypoxic but not hypercapnic drive, possibly as a result of an increase in blood pressure in carotid baroreceptors in µG and the supine position. Limitations: Serious Inconsistency: Serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 79:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Krygiel RG, Waye AB, Baptista RR, Heidner GS, Rehnberg L, Russomano T. The evaluation of upper body muscle activity during the performance of external chest compressions in simulated hypogravity. *Life Sci Sp Res*. 2014; 1(1):60-66. doi:10.1016/ j.lssr.2014.01.004.	Non-randomized controlled trial	20 male participants	0	Performance of 100 chest compressions in simulated martian hypogravity (0,38 G) using a body suspension device	Performance of 100 chest compressions in 1 G	Electromyograph (EMG) activity of four upper body muscles: triceps brachii, erector spinae, upper rectus abdominis, and pectoralis major	All mean values were used in two-tailed t-tests using SPSS to compare +1 Gz values (control) versus simulated hypogravity values. The AHA (2005) compression standards were maintained in hypogravity. RPE and HR increased by in comparison to +1 Gz. In hypogravity, the triceps brachii showed significantly less activity ($p < 0.001$) 32% ($p < 0.001$) and 44% ($p = 0.002$), respectively, when ECCs were performed during Mars simulation, when compared with the other three muscles studied.	Only hypoG, not µG!
Conclusion: Evaluation of a great number of muscles will allow space crews to focus on specific strengthening exercises within their current training regimes in case of a serious cardiac event in hypogravity. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Non-serious **Level of Evidence: Low**								

Study 80:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Groemer GE, Brimacombe J, Haas T, et al. The feasibility of laryngoscope-guided tracheal intubation in microgravity during parabolic flight: A comparison of two techniques. *Anesth Analg*. 2005; 101(5):1533-1535. doi:10.1213/01.ANE. 0000181001.25777.53.	Non-randomized controlled trial	3 participants, 2 male, 1 female	0	Endotracheal intubation during parabolic flight in a free-floating position	Endotracheal intubation during parabolic flight in a restrained position	Ventilation success, time to tube insertion, cause of failure	There were no differences in ventilation success or time to successful insertion between the free-floating condition and the restrained condition. More than 90% of failures were caused by an inability to insert the tracheal tube within 23 s. There were no differences in performance among investigators.	
Conclusion: We conclude that LG-TI is feasible in microgravity obtained during parabolic flight, but success is infrequent because of severe time restrictions. There were no differences in success rate between the free-floating condition, with the manikin's head gripped between the knees, and in the restrained condition, with the torso strapped to a surface. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 81:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Katuntsev VP, Osipov YY, Barer AS, Gnoevaya NK, Tarasenkov GG. The main results of EVA medical support on the Mir Space Station. *Acta Astronaut*. 2004;54(8): 577-583. doi:10.1016 /S0094-5765(03) 00231-5.	Retrospective registry analysis	78 two-person extravehicular activities (EVAs), conducted by thirty-six male crewmembers	0	N/A	Data from performed EVAs	Presence of DCS, other relevant medical conditions	There has been no incidence of DCS during performed EVAs. At the peak activity, metabolic rates and heart rates increased up to 9.9–13 kcal=min and 150–174 min−1, respectively. The medical problems have centred on feeling of moderate overcooling during a rest period in a shadow after the high physical loads, episodes with tachycardia accompanied by cardiac rhythm disorders at the moments of emotional stress, pains in the muscles and general fatigue after the end of a hard EVA. All of the EVAs have been completed safely.	
Conclusion: There have been no incidences of DCS. Physiological responses of cosmonauts corresponded to levels of physical and emotional stress. Physical capabilities of EVA crewmembers during long-term orbital missions have been supported by adequate countermeasures to space deconditioning. Limitations: Serious Inconsistency: Serious Indirectness: Serious Imprecision: Non-serious **Level of Evidence: Low**								

Study 82:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Rehnberg L, Ashcroft A, Baers JH, et al. Three methods of manual external chest compressions during microgravity simulation. *Aviat Sp Environ Med*. 2014;85(7): 687-693. doi:10.3357/ ASEM.3854.2014.	Non-randomized controlled trial	23 male participants	0	Performance of 120 chest compressions in the RBH, HS and RBH position during simulated microgravity using a body suspension device	Performance of 120 chest compressions in conventional position in 1 G	True depth (DT) , ECC rate, and oxygen consumption (VO2)	The mean (+/- SD) DT for the ER (37.4 +/- 1.5 mm) and RBH methods (23.9 +/- 1.4 mm) were significantly lower than +1 G z CPR. However, both methods attained an ECC rate that met the guidelines (105.6 +/- 0.8; 101.3 +/- 1.5 compressions/min). The HS method achieved a superior DT (49.3 +/- 1.2 mm), but a poor ECC rate (91.9 +/- 2.2 compressions/min). VO2 for ER and HS was higher than +1 Gz; however, the RBH was not.	
Conclusion: All three methods have merit in performing ECC in simulated microgravity; the ER and RBH have adequate ECC rates, and the HS method has adequate DT. However, all methods failed to meet all criteria for the 2010 guidelines. Further research to evaluate the most effective method of CPR in microgravity is needed. Limitations: Serious Inconsistency: Non-serious Indirectness: Non-serious Imprecision: Serious **Level of Evidence: Moderate*** *								

Study 83:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Vernalis MN, Latham RD, Fanton JW, Gaffney FA. Transesophageal echocardiographic evaluation of baboons during microgravity induced by parabolic flight. *Physiologist*. 1993;36(1 Suppl):S16-7. http://www.ncbi.nlm.nih.gov/pubmed/11537422.	Observational study	5 male baboons	0	N/A	TEE was performed during parabolic flight	Analysis and measurement of 3 standard views	There was no statistical area change between baseline and the pull-up-phase. During early µG, RA enddiastolic area significantly ($p<.01$) increased. A significant ($p<.05$) increase In RA endsystolic area during early and late OG compared to the ascent phase.	No relevance for CPR guideline
Conclusion: During the acute transition to zero gravity LA and RA chamber areas increased in the EV and VD animals when upright. Furthermore, the echocardiographic area changes paralleled the changes in pressures from the respective chamber when hydrostatic forces were absent. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Non-serious **Level of Evidence: Low**								

Study 84:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Sargsyan AE, Hamilton DR, Nicolaou S, et al. Ultrasound evaluation of the magnitude of pneumothorax: A new concept. *Am Surg*. 2001;67(3):232-235.	N/A	N/A	0	N/A	N/A	N/A	N/A	Partial results of study 73
Conclusion: N/A Limitations: N/A Inconsistency: N/A Indirectness: N/A Imprecision: N/A **Level of Evidence: N/A**								

Study 85:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Thomas SH, Stone CK, Austin PE, March JA, Brinkley S. Utilization of a pressure-sensing monitor to improve in-flight chest compressions. *Am J Emerg Med*. 1995;13(2):155-157. doi:10.1016/0735-6757(95)90083-7.	Non-randomized controlled trial	10 experienced flight nurses	0	Performance of 2 min of chest compressions during helicopter flight utilizing a chest compression feedback system	Performance of 2 min of chest compressions during helicopter flight	Proportion of correct applied chest compressions	The mean proportion of correct compressions (95.7 _-. 3.2%) achieved with utilization of the pressure-sensing monitor was significantly higher (P < .01) than the corresponding proportion for the control group (33.4 -+ 12.1%).	No spaceflight, no µ G, only effect on feedback system
Conclusion: This study demonstrated that the difficulties of performing effective in-flight chest compressions are largely overcome with utilization of a pressure-sensing device providing real-time feedback on compression efficacy. Limitations: Serious Inconsistency: Serious Indirectness: Serious Imprecision: Non-serious **Level of Evidence: Low**								

Study 86:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Karlsson LL, Blogg SL, Lindholm P, Gennser M, Hemmingsson T, Linnarsson D. Venous gas emboli and exhaled nitric oxide with simulated and actual extravehicular activity. *Respir Physiol Neurobiol*. 2009;169(SUPPL.) :60-63. doi:10.1016/ j.resp.2009.04.003.	Observational study	20 participants, 8 female, 12 male	0	N/A	Change in pressure from a space vehicle (1013hPa) to that in a suit for extravehicular activity (EVA) (386hPa) was simulated using a hypobaric chamber over periods of up to 6 h	Usage of Doppler ultrasound to detect any VGE	A large number of VGE were found in one subject at rest, who had a recent arm fracture; a small number of VGE were found in another subject during provocation with calf contractions. No changes in exhaled nitric oxide were found that can be related to either simulated EVA or actual EVA (studied in a parallel study on four cosmonauts).	Low relevance for CPR guideline, possible cause for CA
Conclusion: The present occasional DCI and VGE observations are compatible with a lower risk for DCI in microgravity compared to similar decompressions in normal gravity. Our data further suggest that recent trauma or very strenuous efforts may provoke VGE or DCI. Limitations: Serious Inconsistency: Serious Indirectness: Serious Imprecision: Serious **Level of Evidence: Low**								

Study 87:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
Martin DS, Caine TL, Matz T, et al. Virtual guidance as a tool to obtain diagnostic ultrasound for spaceflight and remote environments. *Aviat Sp Environ Med*. 2012;83(10): 995-1000. doi:10.3357/ ASEM.3279.2012.	Cohort-study	20 participants, 12 female, 8 male	0	N/A	Individuals without previous experience in ultrasound were recruited to perform carotid artery and ophthalmic ultrasound examinations using virtual guidance	Ultrasound image quality was evaluated by independent imaging experts.	Of the studies, 8 of the 10 carotid and 17 of 18 of the ophthalmic images (2 images collected per study) were judged to be diagnostically adequate. The quality of all but one of the ophthalmic images ranged from adequate to excellent.	Feasibility of remote guidance for ultrasound
Conclusion: This form of just-in-time training, which can be applied to other examinations, represents an opportunity to acquire important information for NASA flight surgeons and researchers when trained medical personnel are not available or when remote guidance is impractical. Limitations: Serious Inconsistency: Non-serious Indirectness: Serious Imprecision: Non-serious **Level of Evidence: Low**								

Study 88:

Reference	Study design	Participants	Drop out rate	Intervention	Control	Primary endpoint	Main result	Comment
James JT, Limero TF, Leano HJ, Boyd JF, Covington PA. Volatile organic contaminants found in the habitable environment of the space shuttle: STS-26 to STS-55. *Aviat Sp Environ Med*. 1994;65(9 I):851-857.	Retrospective analysis	N/A	N/A	N/A	N/A	N/A	N/A	Organic contamination aboard the Space Shuttle. No relevance for CPR guideline
Conclusion: N/A Limitations: N/A Inconsistency: N/A Indirectness: N/A Imprecision: N/A **Level of Evidence: N/A**								

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