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Introduction

Indirect calorimetry (IC) remains the best tool to assess resting energy expenditure in critically ill patients and ESPEN as well as ASPEN societies recommend its use [1,2]. Nutritional recommendations have been recently released [3–5] and the use of indirect calorimetry in the COVID-19 infection time remains controversial, mainly because of lack of clear instructions regarding a safe use. ASPEN guidelines [4] state that “while energy requirements can ideally be determined by indirect calorimetry, the principle of “clustering” of care is particularly important and ASPEN recommends instead using weight-based equations to estimate energy requirements as a practical matter for the COVID-19 patients.” AuSPEN guidelines [5] "do not recommend the use of indirect calorimetry (IC) in patients..."
with COVID-19" and ESPEN [3] states that “Energy needs can be assessed using indirect calorimetry if safely available with ensured sterility of the measurement system, or as alternatives by prediction equations or weight-based formulae...” Since our main concern is the personal health professionals safety, we suggest here a guidance to perform indirect calorimetry in an optimal and safe way to ensure an appropriate measurement and energy target determination, according to the use of various metabolic monitors.

1. **Guidance for QNRG+ (Cosmed, Rome, Italy) in ventilated COVID19-patients**

1.1. **Staffing: safety of healthcare practitioners (HCP) is rule number one**

Operators should be familiar with the use of the calorimeter, or trained before action, to limit exposure time, avoid mistakes, use time and resources in an optimal way. As manipulation of the ventilator is involved, we recommend medical doctors or HCP’s familiar with the ‘COVID’ approach to do the connection and disconnection of the device.

1.2. **List up patients**

Check ventilation modes and sedation modes off the floor: how many patients will you measure? Do you need extra material? Will you need to change the sedation mode (sevoflurane switch to Propofol?). Think about timing: when will you approach the patients? Are procedures planned?

1.3. **Procedure and checklist: be prepared — be ready**

All disposables (flow meter, sampling lines, FiO2 adapter, filter) for one measurement should be placed in one plastic bag. All necessary patient information (name, body weight, length,..)should be introduced in software before going bedside.

1.4. **Connection of IC**

a. Apnoe modus or stand by on ventilator
b. Clamping of endotracheal tube
c. Use a plastic, see trough, non-sterile plastic cover over the patient to limit virus spread and still see what you are doing. Discard after use (connection and disconnection).

1.5. **Actual measurement**

Limit time: keep an eye on variability, when <10%, stop recording. Use best 5 min.

1.6. **Disconnection**

a. Stop test on Q-NRG
b. Apnea modus (stand by mode) on ventilator/clamping of tube/plastic cover
c. Remove disposables, wrap in plastic cover and discard.

1.7. **Desinfection**

a. Hand over machine to person non-bedside who handles it with double gloves (follow your local guideline).
b. Total disinfection conform local practice and remove from COVID zone
1.8. Communication and nutritional therapy adaptation

a. Operator checks ventilation modus, condition of patient, sedation.
b. Confirm to nurse procedure is done and state of patient
c. Communicate how results will be managed and how adaptation of nutritional therapy needs to be done.

1.9. Additional practical points provided by the manufacturer

QNRG is a very safe device that, from a hygiene and disinfection point of view, is much safer than a ventilator.

1.9.1. For ventilated patients

All parts in contact with patients are single use (flowmeter, sampling lines, FiO2 adapter). Bacteria and virus filtration of the HME Filter or the Normal Filter (BFE 99.999%, VFE 99.999%) positioned before the flow meter, counteracts any contamination of the device internally.

1.9.2. For canopy test

Use of disposable single-use veils and cleaning procedure of canopy prevent cross contamination. Use of a high efficiency filter (BFE 99.9999%, VFE 99.999%) placed at the canopy blower/port prevent contaminated air to reach the device.

Additional micro filters are placed internally as a redundant safety measure to prevent device contamination.

Patient Inhalation of air from the unit (for both ventilated, canopy and masks) is prevented by the direction of sampling flow (towards device only).

Always follow the indications, instructions and warnings provided in the user manual of the cleaning and disinfectant agent and select only disinfectants with approved efficiency (e.g. FDA clearance or CE mark). The Spaulding classification system, based on the potential risk of infection, establishes the minimum level of reprocessing needed to ensure medical devices are safe for use.

Classification adapted from [6].

| Classification | Equipment/Device                                      | Level of Reprocessing                        | Q-NRG/Q-NRG+ applicable parts*** |
|---------------|-------------------------------------------------------|----------------------------------------------|----------------------------------|
| Critical      | That enters sterile tissues, including the vascular system | Cleaning followed by Sterilization         | N/A                              |
| Semicritical  | That comes in contact with non-intact skin or mucous membranes but does not penetrate them | Cleaning followed by High-Level Disinfection (as a minimum) | Canopy, Mask, Flowmeter          |
| Non Critical  | That touches only intact skin and not mucous membranes, or does not directly touch the patient | Cleaning followed by Low-Level Disinfection (in some cases, cleaning alone is acceptable) | Q-NRG unit, Canopy Hose, Headcap |

[Table 3] *

*** Single use items are not listed as they are meant to be disposed immediately after use thus not undergoing any reprocessing procedures.

Refer to WHO guidelines for infection prevention and control during health care when COVID-19 is suspected."
2. Metabolic modules included in monitors

2.1. General electric (GE) E-sCOVX/E-sCAiOVX modules

2.1.1. Practicalities according to the manufacturer

In ICU the gas flow is always away from the patient. Water trap is acting as a protective filter when the protective membrane is intact. Recommendation for user is to be aware of instruction for use (user manual & IFU in the box) and ask users not to manipulate the water trap to avoid breaking the protective membrane. In addition, reading the warnings from user manual is always beneficial - it would be good to connect a scavenging line to gas sample out connector (in front of the module) to avoid sampled gas discharge in room.

2.1.2. Disinfection and cleaning

About cleaning and disinfection, Bx50/CARESCAPE ONE instructions [7] cover also the X-module. We have good filtering in water traps. For the E-sCOVX/E-sCAiOVX modules there is a D-Fend Pro+ particle separation White Paper available [8,9].

2.2. Mindray

2.2.1. Suggestions for metabolic monitor with confirmed or highly suspected COVID-19 patients

The metabolic monitor is based on Sidestream CO2 module and RM module. To reduce the risk of cross-patient contamination during metabolic monitoring, the following recommendations apply:

2.2.1.1. All components and/or accessories that are in contact with the patient's breathing gas be disposable, such as gas sampling line, RM flow sensor, airway adapter, etc.
2.2.1.2. The water trap on the CO2 or gas module should be replaced after each patient use.

2.2.2. Suggestions for metabolic monitor after usage with confirmed or highly suspected COVID-19 patients

2.2.2.1. Wrap the CO2 and RM module completely with a plastic, cover, and store them safely for a specified time (e.g. 21 or 28 days) at room temperature or higher, and then follow the cleaning and disinfecting procedures in the operator's manual before next use.
2.2.2.2. All the disposable accessories should be removed after each case. To ensure the safe disposal of contaminated devices, please refer to the hospital guideline or local regulations.

3. Case illustration

On picture 1 (from E De Waele), a ventilated COVID19+ patient is undergoing a measurement of indirect calorimetry. A plastic cover is placed during connection and disconnection. Clamping of the tube and connection of the Q-NRG disposable is done under the cover. All the disposables (sampling lines, FiO2 adapter, Filter) are placed on the bed and ready to use.
4. Discussion

With the increasing knowledge regarding the spread of the pandemic [10] and with the improvement in the protection of health care professionals [11], diagnostic and therapeutic approaches such as ECMO have been modified and more codified [12,13]. High flow nasal cannula oxygen therapy that was recommended for a couple of hours at the beginning of the epidemic is now a recommendation of the Surviving Sepsis Campaign for COVID-19 [14]. None of any required procedure has been cancelled in the COVID -19 era, in the same perspective, therefore, we think that the AusPEN position [5] may be too conservative and may prevent to evaluate ICU patients accurately and may induce energy prescription leading to over or under nutrition. A recent position paper is strengthening this position [15]. Metabolic information can be of great value as this largely unknown disease may perturbate the Renin-Angiotensin System and energy metabolism [16].

5. Conclusions

It is mandatory to ensure health professional safety while assessing resting energy expenditure using metabolic monitors. This practical guidance gives the recommended approach to allow a safe metabolic evaluation in critical as well as in ward hospitalized patients. A better evaluation of the metabolic needs will allow a more efficient medical nutritional therapy following the international guidelines.

Conflict of Interest

None declared.
References

[1] Singer P, Blaser AR, Berger MM, Alhazzani W, Calder PC, Caser MP, et al. ESPEN guideline on clinical nutrition in the intensive care unit. Clin Nutr 2019;38:48–79.

[2] McClave SA, Taylor BE, Martindale RG, Warren MM, Johnson DR, Braunschweig C, et al. Guidelines for the provision and assessment of nutrition support therapy in the adult critically ill patient: society of critical care medicine (SCCM) and American society for parenteral and enteral nutrition (A.S.P.E.N.). J Parent Enter Nutr 2016;40:159–211.

[3] Barazzoni R, Bischoff SC, Breda J, Wickramasinghe K, Krznaric Z, Nitzan D, et al. EPEN expert statements and practical guidance for nutritional management of individuals with SARS-CoV-2 infection. Clin Nutr 2020;39:1631–8 [online].

[4] Martindale R, Patel JJ, Taylor B, Warren M, McClave SA. Nutrition therapy in the patient with COVID-19 disease requiring ICU care. J Parenter Enter Nutr 2020. on line, https://www.nutritioncare.org/Guidelines_and_Clinical_Resources/Resources_for_Clinicians_Caring_for_Patients_with_Coronavirus/.

[5] Nutrition management for critically and acutely unwell hospitalised patients with COVID-19 in Australia and New Zealand: executive summary. https://custom.cvent.com/FE8ADE3646EB4896BCEA8239F12DC577/files/93ecb5eadf7244faa98d8948921428a.

[6] Spaulding E. The role of chemical disinfection in the prevention of nosocomial infections. In: Proceedings of the international conference on nosocomial infections, 1970. Chicago, IL: American Hospital Association; 1971. p. 247–548. pdf, https://custom.cvent.com/FE8ADE3646EB4896BCEA8239F12DC577/files/93ecb5eadf7244faa98d8948921428a.

[7] https://www.gehealthcare.com/products/accessories-and-supplies/clinical-accessories-and-supplies#filtration.

[8] https://www.gehealthcare.com/-/jssmedia/046690d1f97e4f339bf9fd9ba172dadfd.pdf.

[9] https://www.gehealthcare.com/-/jssmedia/4445c0d893534c1eb0d80a30cf70f0c1.pdf.

[10] Van Bavel JJ, Baicker K, Willer R. Using social and behavioural science to support COVID-19 pandemic response. Nature Human Behav 2020;4:460–71.

[11] Adams JG, Walls RM. Supporting the health care workforce during the COVID-19 global epidemic. JAMA 2020;323:1439–40.

[12] Phua J, Weng L, Ling L, Egi M, Lim CM, Divatia JV. Intensive care management of coronavirus disease 2019 (COVID-19): challenges and recommendations. Lancet Respir Med 2020;8:506–17.

[13] Ramanathan K, Antognini D, Combes A, Faden M, Zakhary B, Ogino M, et al. Planning and provision of ECMO services for severe ARDS during the COVID-19 pandemic and other outbreaks of emerging infectious diseases. Lancet Respir Med 2020;8:518–26.

[14] Alhazzani W, Møller MH, Arabi YM, Loeb M, Ng Gong M, Fan E, et al. Surviving Sepsis Campaign: guidelines on the management of critically ill adults with Coronavirus Disease 2019 (COVID-19). Intensive Care Med 2020;46:854–87.

[15] Thiebault R, Seguin P, Tamion F, Pichard C, Singer P. Nutrition of the Covid-19 patient in the intensive care unit (ICU): a practical guidance. Critical Care in press.

[16] Mori J, Oudit GY, Lopaschuk GD. SARS-CoV-2 perturbs the renin-angiotensin system and energy metabolism. Am J Physiol Endocrinol Metab 2020 Jul 1;319(1):E43–7. https://doi.org/10.1152/ajpendo.00219.2020. Epub 2020 May 29.