

## PICO ELEMENTS

### 1. POPULATIONS

- a. MILDLY-ILL COVID-19 PATIENTS
- b. COVID-19 PATIENTS with RESP FAILURE
- c. COVID-19 PATIENTS with SEVERE EXTRA-PULM SIGNS & SYMPTOMS

### 2. INTERVENTIONS

- a. LUS ALONE
- b. MULTI-ORGAN POCUS

### 3. COMPARATORS

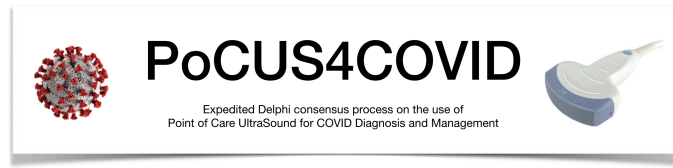
- a. NO LUNG IMAGING
- b. CXR
- c. CT LUNG

### 4. OUTCOMES

- a. MORE EFFECTIVE DX SARS-COV2 INFECTION
- b. MORE EFFECTIVE TRIAGE/DISPOSITION
- c. MORE ACCURATE PULMONARY DX
- d. MORE ACCURATE CVS DX
- e. MORE ACCURATE VTE DX
- f. MORE EFFECTIVE USE OF MECH VENT
- g. MORE APPROPRIATE FLUID MANAGEMENT
- h. MORE EFFECTIVE MONITORING
- i. BETTER INFECTION CONTROL

*Each PICO statement requires you to express your agreement with it based on a Likert scale (0-9): 0-3 = disagreement, 4-6 = uncertainty, 7-9 agreement.*

*The wording of the PICO questions during the 2 rounds of the this streamlined Delphi Technique was not changed substantially.*



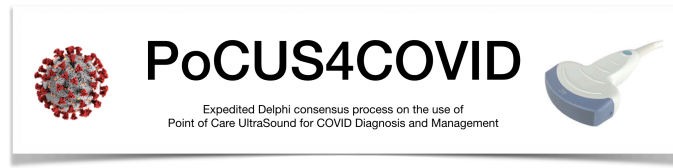
## 1. POPULATIONS

- a. **MILDLY-ILL COVID-19 PATIENTS\*** - presenting to Emergency Department with fever, myalgia, cough, sore throat or other mild symptoms, including exertional dyspnea but not clinically evident acute respiratory failure/hypoxemia, shock, or any other life-threatening or potentially life-threatening condition)
- b. **COVID-19\* PATIENTS\* with RESPIRATORY FAILURE** - including both “Silent Hypoxia” & clinically-overt respiratory failure, either at presentation or along disease course
- c. **COVID-19\* PATIENTS \*with SEVERE EXTRA-PULMONARY SIGNS & SYMPTOMS** - such as shock, altered level of consciousness, stroke, suspected acute thromboembolic disease, acute kidney failure, acute peripheral ischemic disease, either at presentation or along disease course

\* **COVID-19 patients** refers to patients to be screened for SARS-CoV2 infection at first encounter, or already diagnosed with SARS-CoV2 infection . This is where the PICO Outcomes choices apply: e.g. with the Outcome “More effective diagnosis” and “More effective triage/Disposition” (Outcomes a, b) “COVID-19 PATIENTS” refers to patient at first encounter. However, “More effective monitoring” and all the others Outcomes (Outcomes c-i.), may apply either to first-encounter/unknown SARS-CoV2 infection, or already microbiologically demonstrated SARS-CoV2 infection).

## 2. INTERVENTIONS

- a. **LUS ALONE** – Clinically-integrated lung ultrasound and no other PoCUS applications
- b. **MULTI-ORGAN PoCUS** - Clinically-integrated multi-modal, multi-system point-of-care ultrasound, including:
  - Lung Ultrasound
  - Focused Cardiac Ultrasound (+/- hemodynamic measurements)
  - Abdominal scanning of great vessels and kidneys, bladder, gallbladder, liver (potentially including Doppler sampling of kidney artery/vein, Hepatic veins and Portal vein for diagnosis of systemic venous congestion), FAST exam
  - Extremity Duplex compression evaluation for DVT

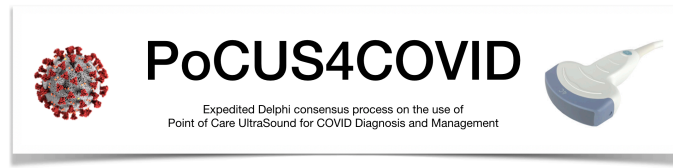


### 3. COMPARATORS

- a. **NO LUNG IMAGING** – Standard/Institutional diagnostic/monitoring clinical workup without the use of any imaging modalities
- b. **CXR** – Standard/Institutional diagnostic/monitoring clinical workup including Chest X-Ray
- c. **CT LUNG** - Standard/Institutional diagnostic/monitoring clinical workup including Chest CT-Scan, plus angio-CT scan if indicated (thoracic great vessels, PE)

### 4. OUTCOMES

- a. **MORE EFFECTIVE DIAGNOSIS OF SARS-COV2 INFECTION**
  - Higher sensitivity, specificity, & accuracy in diagnosing SARS-CoV2 infection
- b. **MORE EFFECTIVE TRIAGE/DISPOSITION** – May include:
  - Higher accuracy at assessment of potential SARS-CoV2 disease
  - Higher accuracy in severity assessment of COVID-19 patients
  - Potentially resulting in more rapid provision and more appropriate level of care and cohorting of patients
- c. **MORE ACCURATE PULMONARY DIAGNOSIS** – May include:
  - Better assessment of pulmonary manifestations and progression of disease
  - Better assessment of pulmonary conditions other than COVID-19 pneumonia
  - Better assessment of superimposed lung conditions
- d. **MORE ACCURATE CVS DIAGNOSIS** – May include:
  - Better assessment of cardiovascular manifestations (shock, cardiac arrest, stroke, peripheral ischemia of the limbs or splanchnic circulation) and progression of disease
  - Better assessment of cardiac complications
- e. **MORE ACCURATE VTE DIAGNOSIS**
  - Better assessment of venous thromboembolic manifestations (PE, DVT) & progression of disease



**f. MORE EFFECTIVE USE OF MECHANICAL VENTILATION – May include:**

- Better assessment of need for MV (non-invasive/invasive)
- More efficient use of MV (help in choice of ventilator modality/settings)
- Better choice of inadequacy of mechanical ventilation and need for extracorporeal support
- Potentially resulting in fewer complications of MV

**g. MORE APPROPRIATE FLUID MANAGEMENT**

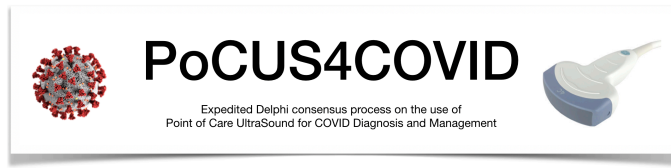
- Better assessment of need of, responsiveness and tolerance to intravenous fluids

**h. MORE EFFECTIVE MONITORING – May include:**

- Better assessment of lung disease course
- Better assessment of lung aeration & recruitment
- Better assessment of hemodynamics
- Better assessment of cardiac disease course
- Better assessment of thromboembolic disease course
- Better assessment of weaning from mechanical ventilation
- Better monitoring of extracorporeal circulation

**i. BETTER INFECTION CONTROL – May include:**

- Reduced in-hospital viral spread
- Lower rate of infection amongst healthcare workers



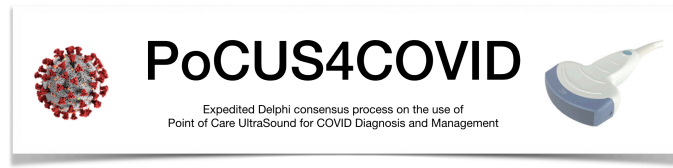
# DELPHI ROUNDS RESULTS - SYNOPSIS

## ROUND 1 - Synopsis

	N	Strength of Consensus				Direction of Agreement		
		VERY GOOD CONSENSUS	GOOD CONSENSUS	SOME CONSENSUS	NO CONSENSUS	AGREE	AMBIV	DISAGREE
Section 1	43	25,6%	49,2%	20,9%	7,0%	86,0%	6,9%	6,9%
Section 2	50	34,0%	46,0%	20,0%	0,0%	64,0%	10,0%	6,0%
Section 2	32	31,3%	59,4%	9,4%	0,0%	93,8%	0,0%	6,2%
Section 4	4	0,0%	100,0%	0,0%	0,0%	50,0%	50,0%	0,0%
<b>TOTALS</b>	129	30,7%	49,6%	17,3%	2,4%	86,6%	8,7%	4,7%

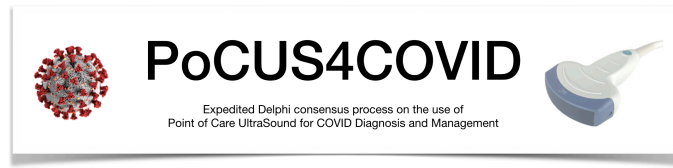
## ROUND 2 - Synopsis

	N	Strength of Consensus				Direction of Agreement		
		VERY GOOD CONSENSUS	GOOD CONSENSUS	SOME CONSENSUS	NO CONSENSUS	AGREE	AMBIV	DISAGREE
Section 1	43	51,2%	25,6%	18,6%	7,0%	83,7%	9,3%	7,0%
Section 2	50	34,0%	54,0%	8,0%	4,0%	84,0%	12,0%	4,0%
Section 2	32	56,3%	31,3%	12,5%	0,0%	93,8%	6,3%	0,0%
Section 4	4	0,0%	75,0%	25,0%	0,0%	100,0%	0,0%	0,0%
<b>TOTALS</b>	129	44,2%	39,5%	13,2%	3,9%	86,8%	9,3%	3,9%



## PoCUS4COVID Domains

<b>DOMAIN</b>	<b>PoCUS APPLICATION</b>
1	DIAGNOSIS OF SARS-COV2 INFECTION
2	TRIAGE/DISPOSITION
3	DIAGNOSIS OF COVID-19 PNEUMONIA
4	CARDIOVASCULAR DIAGNOSIS
5	SCREENING AND DIAGNOSIS OF THROMBOEMBOLIC DISEASE
6	PoCUS AND RESPIRATORY SUPPORT STRATEGIES
7	MANAGEMENT OF FLUID ADMINISTRATION
8	MONITORING OF COVID-19 PATIENTS
9	INFECTION CONTROL, TECHNIQUES, TECHNOLOGY AND PROTOCOLS



# RESULTS and SUMMARY RECOMMENDATIONS

## DOMAIN 1 - PoCUS FOR DIAGNOSIS OF SARS-CoV2 INFECTION

<b>1 - SARS DX</b>	<b>TOTAL N = 18</b>	<b>%</b>	<b>MILD N = 7</b>	<b>RESP FAIL N = 7</b>	<b>XTR-PULM N = 4</b>
VG	0	0,0%	0	0	0
G	10	55,6%	3	5	2
S	6	33,3%	3	1	2
NC	2	11,1%	1	1	0
<b>AGREE</b>	10	55,6%	4	4	3
<b>AMBIV</b>	2	11,1%	2	2	1
<b>DISAGREE</b>	5	27,8%	1	1	0

<b>GRADEing</b>		<b>N = 11</b>	<b>IBID</b>	<b>CONS</b>
<b>2A</b>	<b>2B</b>	<b>3</b>		<b>G</b>
5	4	2	3	

## DOMAIN 2 - PoCUS AS A TOOL FOR TRIAGE/DISPOSITION

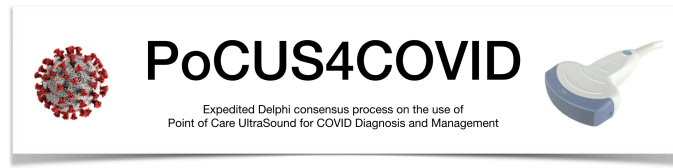
<b>2 - TRG/DISP</b>	<b>TOTAL N = 18</b>	<b>%</b>	<b>MILD N = 7</b>	<b>RESP FAIL N = 7</b>	<b>XTR-PULM N = 4</b>
VG	5	27,8%	2	1	2
G	11	61,1%	4	5	2
S	2	11,1%	1	1	0
NC	0	0,0%	0	0	0
<b>AGREE</b>	16	88,9%	6	6	4
<b>AMBIV</b>	2	11,1%	1	1	0
<b>DISAGREE</b>	0	0,0%	0	0	0

<b>GRADEing</b>		<b>N = 14</b>	<b>CONS</b>
<b>2A</b>	<b>2B</b>	<b>3</b>	<b>G</b>
1	7	6	

## DOMAIN 3 - PoCUS AS A TOOL FOR TRIAGE/DISPOSITION

<b>3 - PULM DX</b>	<b>TOTAL N = 18</b>	<b>%</b>	<b>MILD N = 7</b>	<b>RESP FAIL N = 7</b>	<b>XTR-PULM N = 4</b>
VG	7	38,9%	4	2	1
G	4	22,2%	0	3	1
S	4	22,2%	1	1	2
NC	3	16,7%	2	1	0
<b>AGREE</b>	13	72,2%	5	5	3
<b>AMBIV</b>	2	11,1%	0	1	1
<b>DISAGREE</b>	3	16,7%	2	1	0

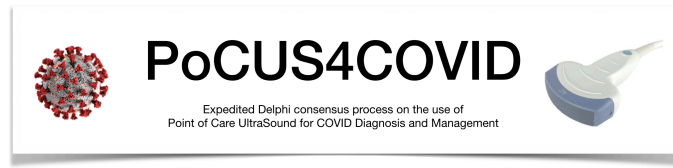
<b>GRADEing</b>		<b>N = 53</b>	<b>CONS</b>
<b>2A</b>	<b>2B</b>	<b>3</b>	<b>G</b>
5	18	28	



## Recommendations

- 1) We suggest using PoCUS, and especially LUS (presence of heterogeneous B-line clusters, pleural line irregularities, subpleural consolidations), and appropriately integrate the information with clinical assessment to diagnose COVID-19 pneumonia (**LQE II-B, Very Good Agreement**).
- 2) When CT-scan is not accessible or appropriate, we suggest using LUS to aid the diagnosis of COVID-19 pneumonia in suspected cases (**LQE II-B, Good Agreement**).
- 3) In patients with high pre-test probability for COVID-19 and LUS findings suggestive of pneumonia, a negative nasal/oropharyngeal RT-CR may not be used to exclude COVID-19, and LUS findings, further raising suspicion, should prompt repeat testing with better yield (**LQE II-B, Good Agreement**).
- 4) We do *not* recommend using PoCUS and LUS alone to rule out SARS-CoV-2 infection in suspected COVID-19 (LQE II-B, Good Agreement).
- 5) After thorough examination of all lung fields and intercostal spaces a bilateral A-pattern suggests absence of pneumonia in suspected or confirmed SARS-CoV-2 infection (**LQE III, Good Agreement**).
- 6) We suggest multi-organ PoCUS integrated with other clinical information for triaging and risk stratification of suspected COVID-19 at initial presentation (**LQE II-B, Good Agreement**).





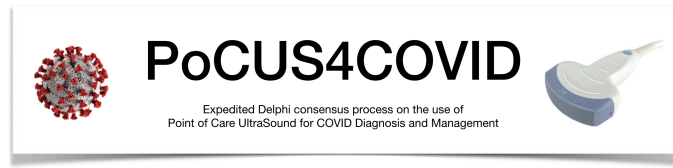
## DOMAIN 4 - FoCUS, AND COMPREHENSIVE ECHOCARDIOGRAPHY FOR THE CARDIOVASCULAR DIAGNOSIS IN COVID-19 PATIENTS

4 - CVS DX	TOTAL N = 12	%	MILD N = 4	RESP FAIL N = 4	XTR-PULM N = 4
VG	10	83,3%	4	3	3
G	2	16,7%	0	1	1
S	0	0,0%	0	0	0
NC	0	0,0%	0	0	0
<b>AGREE</b>	<b>12</b>	<b>100,0%</b>	<b>4</b>	<b>4</b>	<b>4</b>
<b>AMBIV</b>	<b>0</b>	<b>0,0%</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>DISAGREE</b>	<b>0</b>	<b>0,0%</b>	<b>0</b>	<b>0</b>	<b>0</b>

GRADEing			N = 26	CONS
2A	2B	3		
1	10	15	49	VG

### Recommendations

- 7) We suggest FoCUS and/or echocardiography assessment in moderate-severe COVID-19 as it may change clinical management or provide information that could be lifesaving **(LQE II-B, Very Good Agreement)**.
- 8) We suggest FoCUS and/or echocardiography for assessment of hemodynamic instability in moderate-severe COVID-19 **(LQE II-B, Very Good Agreement)**.
- 9) We recommend FoCUS and echocardiography to diagnose RV and LV systolic dysfunction and cardiac tamponade as etiology of hemodynamic instability in COVID-19 **(LQE II-B, Very Good Agreement)**.
- 10) We suggest using FoCUS/echocardiography to guide hemodynamic management in severe COVID-19 **(LQE II-B, Very Good Agreement)**.

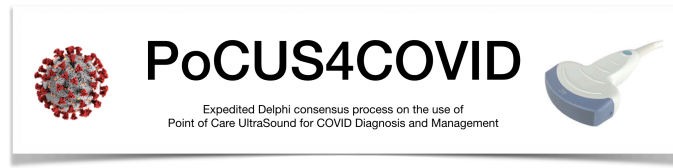


**DOMAIN 5 - PoCUS FOR SCREENING AND DIAGNOSIS OF COVID-19 PATIENTS FOR VENOUS THROMBOEMBOLIC DISEASE (VTE)**

5 - VTE DX	TOTAL		MILD	RESP FAIL	XTR-PULM	GRADEing	N = 32			CONS
	N = 12	%	N = 4	N = 4	N = 4	2A	2B	3	12	VG
VG	9	75,0%	3	3	3	10	12	10		
G	2	16,7%	1	1	1					
S	1	8,3%	0	0	0					
NC	0	0,0%	0	0	0					
AGREE	12	100,0%	4	4	4					
AMBIV	0	0,0%	0	0	0					
DISAGREE	0	0,0%	0	0	0					

**Recommendations**

- 11) Because critically ill COVID-19 patients have high risk for VTE, we suggest regular screening for DVT, including central vessels with catheters, independent of oxygenation and coagulation (**LQE II-A, Very Good Agreement**).
- 12) In moderate-severe COVID-19 with hemodynamic worsening or sudden instability we suggest FoCUS for prompt investigation of acute cor-pulmonale (**LQE II-B, Very Good Agreement**).
- 13) In moderate-severe COVID-19 we suggest that echocardiographic indices of worsening RV function and/or increased pulmonary artery pressure may indicate PE (**LQE II-A, Very Good Agreement**).



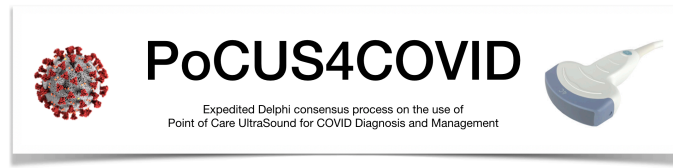
## DOMAIN 6 - PoCUS AND RESPIRATORY SUPPORT STRATEGIES [INCLUDING MECHANICAL VENTILATION] IN PATIENTS WITH COVID-19 PNEUMONIA

6 - RESP SUPP	TOTAL		MILD	RESP FAIL	XTR-PULM
	N = 11	%	N = 0	N = 7	N = 4
VG	4	36,4%	0	2	2
G	7	63,6%	0	5	2
S	0	0,0%	0	0	0
NC	0	0,0%	0	0	0
AGREE	10	90,9%	0	6	4
AMBIV	1	9,1%	0	1	0
DISAGREE	0	0,0%	0	0	0

GRADEing		N = 20		CONS
2A	2B	3	35	G
2	11	7	36	
			41	

### Recommendations

- 14) We suggest multi-organ PoCUS including LUS over no imaging to guide respiratory support in COVID-19 with respiratory failure (i.e. ventilation, prone positioning, PEEP, recruitment maneuvers) (**LQE II-A, Good Agreement**).
- 15) In addition to standard respiratory monitoring, we suggest LUS over CXR and equally to CT, to guide clinical decisions on respiratory support in COVID-19 with respiratory failure (**LQE II-B, Good Agreement**).
- 16) We suggest multi-organ PoCUS over LUS alone for decisions about respiratory support in COVID-19 with respiratory failure (**LQE II-B, Good Agreement**).



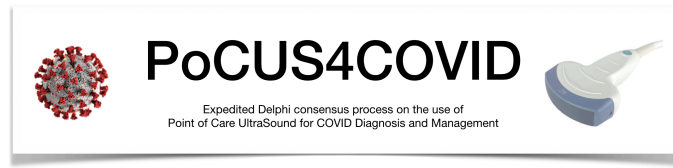
## **DOMAIN 7 - PoCUS FOR MANAGEMENT OF FLUID ADMINISTRATION IN COVID-19 PATIENTS**

<b>7 - FLD MAN</b>	<b>TOTAL</b>		<b>MILD</b>	<b>RESP FAIL</b>	<b>XTR-PULM</b>
	<b>N = 18</b>	<b>%</b>	<b>N = 7</b>	<b>N = 7</b>	<b>N = 4</b>
<b>VG</b>	11	61,1%	4	3	4
<b>G</b>	5	27,8%	1	4	0
<b>S</b>	2	11,1%	2	0	0
<b>NC</b>	0	0,0%	0	0	0
<b>AGREE</b>	16	88,9%	6	6	4
<b>AMBIV</b>	2	11,1%	1	1	0
<b>DISAGREE</b>	0	0,0%	0	0	0

<b>GRADEing</b>		<b>N = 9</b>			<b>CONS</b>
<b>2A</b>	<b>2B</b>	<b>3</b>	<b>5</b>	<b>VG</b>	
0	7	2			

### **Recommendations**

- 17) We suggest FoCUS to screen for severe hypovolemia in moderate-severe COVID-19 at presentation, while Doppler-based fluid-responsiveness indices may be used for subsequent management (**LQE II-A, Very Good Agreement**).
- 18) We suggest that LUS alone is not sufficient as a screening tool for pulmonary congestion in moderate-severe COVID-19 (**LQE III, Very Good Agreement**).
- 19) We suggest that LUS alone is not sufficient to judge the appropriateness of fluid administration in moderate-severe COVID-19 (**LQE II-B, Very Good Agreement**).
- 20) In moderate-severe COVID-19 we suggest multi-organ PoCUS to monitor efficacy of fluid removal, by not only LUS findings of reduction of B-pattern areas, but also echocardiographic signs of resolution of volume overload and decreasing LV filling pressures (**LQE II-B, Very Good Agreement**).



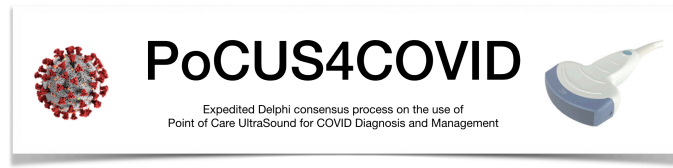
## **DOMAIN 8 - PoCUS AS MONITORING TOOL FOR PATIENTS WITH COVID-19**

<b>8 - MONITOR</b>	<b>TOTAL</b>		<b>MILD</b>	<b>RESP FAIL</b>	<b>XTR-PULM</b>
	<b>N = 18</b>	<b>%</b>	<b>N = 7</b>	<b>N = 7</b>	<b>N = 4</b>
<b>VG</b>	11	61,1%	5	3	3
<b>G</b>	7	38,9%	2	4	1
<b>S</b>	0	0,0%	0	0	0
<b>NC</b>	0	0,0%	0	0	0
<b>AGREE</b>	18	100,0%	7	7	4
<b>AMBIV</b>	0	0,0%	0	0	0
<b>DISAGREE</b>	0	0,0%	0	0	0

<b>GRADEing</b>		<b>N = 49</b>		<b>CONS</b>
<b>2A</b>	<b>2B</b>	<b>3</b>	<b>10</b>	<b>VG</b>
4	29	16	11	
			25	
			49	
			51	
			64	
			66	
			67	

### **Recommendations**

- 21) We suggest serial LUS for respiratory monitoring in moderate-severe COVID-19 (**LQE II-B, Very Good Agreement**).
- 22) We suggest multi-organ PoCUS integrated with other clinical and biochemical variables, in preference to CXR for investigation of respiratory deterioration in moderate-severe COVID-19. (**LQE II-A, Very Good Agreement**).
- 23) We suggest multi-organ PoCUS over LUS alone to detect respiratory deterioration and guide treatment in moderate-severe COVID-19. (**LQE II-B, Very Good Agreement**).
- 24) We suggest a prompt assessment of clinical deterioration with LUS for a timely and accurate bedside diagnosis of pneumothorax in severe COVID-19 (**LQE II-B, Very Good Agreement**).
- 25) We suggest LUS for early identification of ventilator-associated pneumonia in severe COVID-19 (**LQE II-B, Very Good Agreement**).
- 26) We suggest multi-organ PoCUS over CXR and CT to assess readiness for weaning, predict success, and diagnose the cause(s) of weaning failure in COVID-19 (**LQE II-B, Very Good Agreement**).
- 27) We suggest FoCUS, and/or echocardiography for hemodynamic monitoring in moderate-severe COVID-19 (**LQE II-A, Very Good Agreement**).
- 28) We suggest integrating PoCUS-derived information with data from other devices used for hemodynamic monitoring in severe COVID-19 (**LQE II-B, Very Good Agreement**).
- 29) We suggest PoCUS assessment for pre-renal causes of AKI, including hemodynamics and venous congestion in COVID-19 (**LQE II-B, Very Good Agreement**).



## **DOMAIN 9 - PoCUS AND INFECTION CONTROL, PoCUS TECHNIQUE, TECHNOLOGY, PROTOCOLS**

<b>9 - INF CON</b>	<b>N = 4</b>	<b>%</b>		
<b>VG</b>	<b>0</b>	<b>0,0%</b>		
<b>G</b>	<b>3</b>	<b>75,0%</b>		
<b>S</b>	<b>1</b>	<b>25,0%</b>		
<b>NC</b>	<b>0</b>	<b>0,0%</b>		
<b>AGREE</b>	<b>4</b>	<b>100,0%</b>		
<b>AMBIV</b>	<b>0</b>	<b>0,0%</b>		
<b>DISAGREE</b>	<b>0</b>	<b>0,0%</b>		

<b>GRADEing</b>			<b>N = 23</b>		<b>CONS</b>
<b>2A</b>	<b>2B</b>	<b>3</b>			<b>G</b>
<b>4</b>	<b>14</b>	<b>5</b>			

### **Recommendations**

- 30) We suggest using laptop/tablet/pocket-sized devices with adequate imaging capabilities that are easier to protect from viral contamination in COVID-19 **(LQE II-B, Good Agreement)**.
- 31) For diagnostic accuracy, quality control and obtaining second opinions, we suggest performance of standardized PoCUS examinations in COVID-19 **(LQE II-B, Good Agreement)**.
- 32) We recommend reporting PoCUS studies and recording, storage and archiving of diagnostic images and cine-clips **(LQE II-B, Good Agreement)**.
- 33) We suggest using tele-ultrasound for remote guidance and consultations in COVID-19. Simple audio-visual communication devices (e.g. smartphones) can facilitate this **(LQE II-B, Good Agreement)**.
- 34) We suggest POCUS over CXR and CT, where appropriate, to reduce environmental spread of infection and risk of infection to healthcare workers in COVID-19 **(LQE II-A, Good Agreement)**.
- 35) We recommend strict adherence to manufacturers' guidance for cleaning and disinfection of equipment used for COVID-19 **(LQE II-A, Good Agreement)**.
- 36) We suggest brief and targeted ultrasound examinations to minimize cross-infection in COVID-19 **(LQE II-B, Good Agreement)**.