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Cohort Study

Multidisciplinary team approach in critically ill COVID-19 patients reduced pronation-related complications rate: A retrospective cohort study

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A R T I C L E I N F O

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A B S T R A C T

Background: In the pandemic scenario, critically ill COVID-19 patients' management presented an increased workload for Intensive Care Unit (ICU) nursing staff, particularly during pronation maneuvers, with high risk of complications. In this contest, some authors described an increase in complications incidence after pronation. An *ICU Pronation Team* (IPT) was implemented to support this maneuver.

Material and methods: Retrospective analysis was conducted on consecutive critically ill COVID-19 patients in COVID-19 Center in southern Switzerland, between March and April 2020. Aim of the study was to determine rates and characteristics of pronation-related complications managed by IPT according to standard protocols.

Results: Forty-two patients undergoing mechanical ventilation (MV) were enrolled; 296 prone/supine positioning were performed, with 3.52 cycles/patient. All patients were equipped with arterial line, central venous catheter, urinary catheter, 28 (66%) endotracheal tube, 8 (19%), tracheostomy, 6 (14%) dialysis catheter, 3 (7%) abdominal drainage and 8 (19%) femoral thermodilution catheter; mean BMI was 28.3 kg/m^2. One (0.3%) major complication was observed, while fourteen (33.3%) patients developed minor complications (pressure injuries). ICU length-of-stay and MV days correlated with both incidence ($p = 0.029$ and $p = 0.015$ respectively) and number ($p = 0.001$ and $p = 0.001$ respectively) of pressure sores ($n = 27$). Propensity matching score analysis did not show any protective factor of pronation regarding pressure injuries ($p = 0.448$). No other significant correlation was found.

Conclusion: Multidisciplinary healthcare professional management can reduce most severe complication related to pronation in critical care setting. Rather than from pronation, the persistent high rate of minor complications appeared to be related to disease severity.

1. Introduction

COVID-19 pneumonia is a viral disease caused by SARS-CoV-2, affecting over 209,000,000 patients, with 4,300,000 deaths worldwide [1]. A relevant aspect in critically ill COVID-19 patients concerns the acute respiratory failure due to severe interstitial bilateral pneumonia, often requiring mechanical ventilation (MV) through endotracheal intubation, or tracheostomy if MV is prolonged [2–4]. Consequentially, the burden of COVID-19 patients management for the ICU nursing staff is greatly increased [5]. Pronation maneuvers are an important element in managing patients undergoing mechanical ventilation for respiratory failure and Acute Respiratory Distress Syndrome (ARDS), in order to increase tissue oxygenation through an improvement in the ventilation/perfusion mismatch [6,7]. This maneuver requires a degree of physical effort, as well as the presence of multiple healthcare professionals for a correct execution of the technical gesture [8,9].

Conflicting data regarding pronation-related complications in ARDS patients have been reported. Some authors described an increase in

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complications incidence after pronation, particularly concerning pressure ulcers, endotracheal tube obstruction and unscheduled extubation [10–13], while other groups did not find an increased risk of complications [14–16], possibly due to the presence of highly experienced and qualified personnel [15–18]. Similarly, some groups addressed the incidence of pronation-related complications in critically ill COVID-19 patients [19,20]. In this setting, Short et al. [21] reported a clinical benefit in having a specific "pronation team" dedicated to patients' pronation during the pandemic wave [22], even though they focused mainly over clinical patients evolution, rather than over the rate of complications related to this delicate procedure.

During the first weeks of the pandemic, a high ICU workload was immediately registered [5], including an increased number of pronations, with consequent increase in the incidence of related complications. In this emergency scenario, our Clinic, having been identified as a COVID-19 Center by the Swiss Health Department [2], decided to introduce physiotherapists in supporting to nurses activities, organizing an *ICU Pronation Team* (IPT) [17], dedicated to the correct performance of this delicate and important clinical maneuver. In this study, we aimed to retrospectively analyze the complications rate related to pronation in critically ill COVID-19 patients, standardly treated by a dedicated IPT.

2. Methods

We performed a retrospective cohort study analysis including consecutive critically ill COVID-19 patients admitted to our Intensive Care Unit (ICU) from March 16 to April 30, 2020, this being the only inclusion criteria; all patients not undergoing mechanical ventilation (MV) and/or pronation cycles were excluded from the analysis. Demographic data such as age and Body-Mass Index (BMI), comorbidities such as chronic-obstructive pulmonary disease (COPD), obstructive sleep apnea syndrome (OSAS), diabetes, hypertension and ischemic heart disease (IHD) were registered and reported. Evaluation of ICU severity scores at admission (NEMS - Nine equivalents of nursing manpower use score -, SAPS - Simplified Acute Physiology Score - and SOFA - Sequential Organ Failure Assessment -), and MV features such as endotracheal intubation, need for tracheostomy, days of MV, ICU length-of-stay (LOS) and number of pronation cycles were also reported. Data about the number and type of devices (endotracheal tube, arterial line, central venous line, thoracic/abdominal catheter, urinary catheter, dialysis catheter) were also collected. Patients on MV were further stratified in those undergoing invasive MV (endotracheal intubation and tracheostomy) and non-invasive MV (C-PAP, High-Flow or nasal cannula oxygen-therapy). Data regarding actual and past ICU workload (NEMS, SAPS and SOFA) were extrapolated from a public national dataset [23], using queries concerning *critical patients [admitted in ICU] AND first pandemic wave [from March 16, 2019 to April 16, 2019] AND [primary diagnosis of pulmonary infection]*; all data were collected and reported in the electronic medical record.

2.1. Indication to pronation

Standardized clinical criteria for pronation included critically ill COVID-19 patients undergoing MV with ARDS criteria [4] and a P/F-ratio less than 150 despite standard-of-care management, associated with a protective MV (low-volume, low-pressure ventilation and adequate ventilator synchrony) [24], with FiO_2 more than 60% and PEEP titrated according to ARDS network [24]. Pronation cycles were continued until the P/F-ratio remained less than 150 when supine, with FiO_2 greater than 60% and PEEP greater than 10 cmH_2O.

2.2. Pronation gesture

The IPT was essential for critically ill COVID-19 patients' systematic pronation; it was constituted by a nurse and by a minimum of four physiotherapists. Based on patients' clinical status and evolution, after a short assessment with the Intensivist in charge, pronations took place every day at 4.00 p.m., 7 days per week; the supinations occurred instead at 8.00 a.m., unless clinicians did not provide a different indication, with an average duration of pronation of 16 h per day.

The pronation gesture was executed according to international standards concerning pronation methodology, monitoring and pressure injuries prevention [22,25]. During the pronation maneuvers, the nurse in charge managed the head and the main devices (such as endotracheal tube, central venous catheter, dialysis catheter), coordinating the IPT during the maneuver and ensuring the correct execution and timing of the gesture. Physiotherapists were positioned in pairs on both sides of the patient, to perform pronation according to the nurse's indications; two physiotherapists managed pronation of the thoraco-abdominal area, while other two managed the legs and the urinary catheter. Data concerning total number of patient pronation cycles, specific devices and all pronations-related data were recorded in the electronic medical database.

2.3. Complications of pronation

In accordance with Lucchini et al. [18] and Kimmoun et al. [20], pronation-related adverse events were stratified into major and minor complications [12,13,26,27]. Major complications were cardiac arrest, unscheduled extubation, accidental endotracheal tube displacement, displacement of other devices (central venous catheter, thoracic or abdominal drainage), loss of peripheral vascular access, bone dislocations. Minor complications were the presence of pressure injuries, reported according to severity stage, number of sores and location [12,13,26,27]. All information reported in the electronic medical record has been collected.

2.4. Endpoints

The **primary** endpoint was to retrospectively report and analyze major complications rates in critically ill COVID-19 patients managed by the IPT. **Secondary** endpoints were to report the incidence and severity of minor complications (pressure injuries), identifying any potential risk or preventive factors associated with them.

2.5. Statistical analysis

A descriptive statistic was conducted; data were reported as number (percentage). Data distribution was reported as mean (SD) or as median (IQR) according to the statistical distribution, verified by Kolmogorov-Smirnov test. Differences between patient outcomes were studied by *t*-test for independent groups or by Wilcoxon test if non-parametric analysis was required. Study of differences between groups of categorical data was carried out by Chi-square statistics. To assess the impact of treatment (pronation/non-pronation) on complications incidence and to control for confounding factors, a propensity score-adjusted multivariable analysis through available data was performed. Quantitative variables like age, BMI, MV days, ICU LOS, and the scores at admission of SAPS, NEMS and SOFA were used; qualitative variables like sex, presence of tracheostomy or IOT, presence of comorbidities like hypertension, OSAS, COPD, diabetes, ischemic heart disease and presence of complications like VAP, need of CVVHDF during recovery, other types of infection and pulmonary thromboembolism were determined. The level of significance was established to be $p < 0.05$. Statistical data analysis was performed using SPSS (version 25.0; IBM Corp, Armonk, New York, USA).

2.6. Ethical consideration

This study has been reported in line with the STROCSS criteria [28], and has been submitted to the Research Registry (unique identifying number "researchregistry7067") [29]. This study has been notified to the Ethics Committees (Comitato Etico Cantonale, CE_TI 3763), and it has been approved in agreement with the local Federal rules. Informed consent was obtained from patients involved in the analysis.

3. Results

During the study period, 43 consecutive critically ill COVID-19 patients were admitted to our ICU, of whom 42 were included in the analysis; one patient was excluded because he did not undergo MV and/or pronation. All included patients underwent MV, with 36 patients (86%) underwent invasive MV (66% ventilated through endotracheal tube and 19% through tracheostomy); each patient were equipped with an arterial line (42, 100%), a central venous catheter (42, 100%) and a urinary catheter (42, 100%), 6 (14%) patients had a dialysis catheter (2 in jugular site, 4 in femoral site), 3 (7%) patients had an abdominal drainage and 8 patients (19%) were equipped with an extra femoral catheter for thermodilution; a mean BMI resulted 28.3 kg/m^2 (18.6–41.1, SD 5.1). Median age was 67.5 years (56.7–73 yrs), 35 (83.3%) were male; the median ICU LOS for all patients was 11 days (8–18) with a median length of MV days of 8 days (5–13). At admission, mean SAPS score was 46.1 (13–94, SD 18), median SOFA score 7 (4–8.25) and median NEMS score was 34.5 (18–39) (Table 1). The mean NEMS value in patients admitted to our ICU for COVID-19 related pulmonary complication resulted 30.5 (9–42, SD 10.1). This result was compared to the mean NEMS of patients with similar clinic characteristic admitted to the ICU during the previous year, 22.6 (9–48, SD 8.2), showing an annual significant augmentation of workload ($p < 0.001$).

3.1. Primary outcome

During the study period, 296 technical gestures of pronation and supination (148 pronation cycles) were performed by the IPT on MV patients (Table 2), with an average of 3.52 cycles per patient (1–8, SD 2.47). During pronation, one major complication was observed (0.3%), consisting in the accidental endotracheal tube displacement. This complication was associated with sudden peripheral desaturation and was confirmed by emergency bronchoscopy, without any subsequent clinical consequence after its rapid management. No other major complications were registered (Table 2).

Table 1
Patients' demographics characteristics.

	Characteristics	Enrolled (n = 42)
Demographics	Age	67.5 (56.75–73)
	Male	35 (83.3)
	BMI	28 (18.6–41.1, SD 5.1)
Comorbidities	Hypertension	20 (47.6%)
	Diabetes	14 (33.3%)
	OSAS	6 (14.3%)
	COPD	5 (11.9%)
	Heart Ischemic Disease	9 (21.4%)
	VTE	7 (16.7%)
Severity score at ICU admission	NEMS	34.5 (18–39)
	SAPS II	46.1 (13–94, SD 18.22)
	SOFA	7 (4–8.25)
MV parameters	Patients on invasive MV	36 (86%)
	• Endotracheal tube	28 (66%)
	• Tracheostomy	8 (19%)
	Pronation maneuvers	3.52 (1–8, SD 2.48)
	ICU LOS (n = 42)	11 (6–18)
	MV Days (n = 36)	8 (5–13)
Patients' equipment	Endotracheal tube	28 (66%)
	Tracheostomy	8 (19%)
	Arterial line	42 (100%)
	Central Venous Line	42 (100%)
	Urinary catheter	42 (100%)
	Dialysis catheter	6 (14%)
	Abdominal drainage	3 (7%)
	Femoral thermodilution catheter	8 (19%)

Demographic characteristics at ICU admission. Data are presented as means (min-max, SD) or medians (IQR) according to data distribution.

Table 2
Major Complications related to pronation.

Number of pronations	296
Cardiac arrest	0
Unscheduled extubation	0
Endotracheal tube displacement	1 (0.3)
Displacement of devices	0
Loss of peripheral vascular access	0
Bone dislocations	0

ICU major complications directly related to pronation. Data are presented as numbers and percentual.

3.2. Secondary outcomes

Despite the prone position, 14 (33.3%) patients presented minor complications consisting in pressure injuries; 8 (19%) patients showed a single pressure sore, 2 (4.8%) patients presented 2 lesions, 3 (7.1%) patients had 3 lesions and 1 (2.4%) patient presented 5 different pressure injuries. Data regarding lesion distribution and staging are reported in Table 3. However, pressure injury distribution did not involve areas with major pressure, with sacral decubitus occurring in 33.3% of patients, even if they remained pronated for 16 h/day. The *number* of pressure injuries presented significant correlations with MV days ($r = 0.475$, $p = 0.001$) (Fig. 1), and ICU LOS ($r = 0.467$, $p = 0.001$) (Fig. 2); similarly, the *presence* of pressure injuries also correlated with ICU LOS ($p = 0.029$) and MV days ($p = 0.015$, Fig. 2). No significant correlation was found with other variables (Table 4).

Because of the retrospective design of the study and the imbalance between treatments for different patients, a propensity score was applied with the aim to better estimate the effect of observed data. The propensity matching score showed no protective factor of pronation in relation to the incidence of pressure injuries ($p = 0.448$).

4. Discussion

To date, several groups have approached the problem regarding the creation of a dedicated team in order to better manage the high number of pronations in critically ill COVID-19 patients [19,21,22,30,31]. However, no study reported data concerning the impact of a dedicated team that avails itself of the support of physiotherapists on the incidence of pronation-induced complications. In accordance with Lucchini et al. [5], current data confirmed the evidence that the nursing workload for critically ill COVID-19 patients was more increased compared to previous years. In this scenario, better procedural management requires a

Table 3
Stratification of pressures injuries related to pronation, according to degree and anatomical site.

	Degree I	Degree II	Degree III	Degree IV	Total
Chest	1 (3.7)	5 (18.5)	0	0	**6 (22.2)**
Sacred	2 (7.4)	3 (11.1)	4 (14.8)	0	**9 (33.3)**
Chin	0	2 (7.4)	1 (3.7)	0	**3 (11.1)**
Lip rhyme	0	1 (3.7)	0	0	**1 (6.25)**
Knee	2 (7.4)	1 (3.7)	0	0	**3 (11.1)**
Cheek	0	2 (7.4)	1 (3.7)	0	**3 (11.1)**
Hip	0	1 (3.7)	0	0	**1 (6.25)**
Gluteus	0	1 (3.7)	0	0	**1 (6.25)**
Total	**5 (18.5)**	**16 (59.2)**	**6 (22.2)**	**0**	**27 (100)**

Pressure injuries degrees and sites. The greatest prevalence of lesions occurs at sacral level, an anatomical area that mechanically should be preserved from compression with pronation. Data are presented as numbers and percentual.

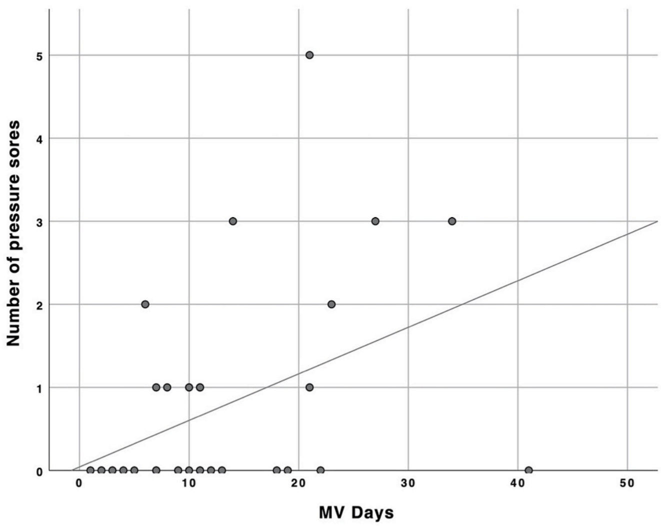

Fig. 1. MV days and pressure injuries. Patients' distribution comparing MV days and pressure injuries (r = 0.475, p = 0.001).

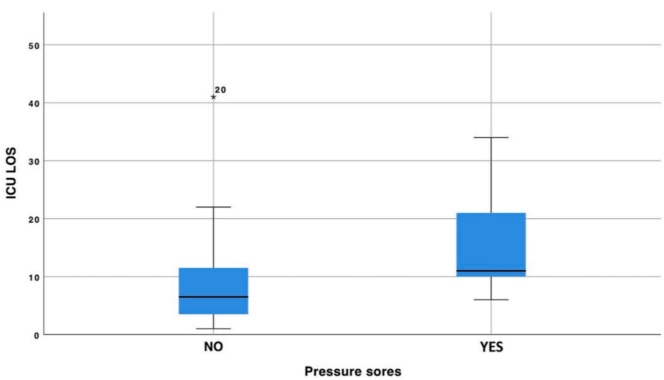

Fig. 2. ICU LOS and pressure injuries. Correlation between ICU LOS distribution and the presence/absence of pressure injuries (p = 0.029).

multidisciplinary approach, with the aim to reduce pronation complication rates.

In the current cohort study, only one case of major complication induced by pronation was registered, in contrast with the meta-analysis of Sud et al. [10,12], in which major and minor complications presented a greater incidence in ARDS patients placed in the prone position. In particular, as major complications they reported an increased risk of endotracheal tube obstruction (RR 1.58), thoracostomy tube dislodgement (RR 3.14) or unplanned central venous line or arterial line removal [12]. On the basis of these results, and in accordance with Guerin et al. and Abroug et al. [15,16], we hypothesize that the implementation of a trained specialized team involved in the pronation maneuver of critically ill COVID-19 patients is a potential protective factor, aiding in reducing the incidence of pronation-induced major complications.

Concerning minor complications, a different outcome was identified. Sud et al. [10,12] highlighted as pressure ulcers incidence resulted increased (RR 1.29) during pronation in ARDS patients; similarly, despite the IPT involvement, we reported the persistence of pressure injuries in one third of critically ill COVID-19 patients. Current data induced us to consider COVID-19 as a strongly debilitating disease in terms of catabolic energy balance [32]. This hypothesis is supported by the identification of a direct correlation between MV days and ICU LOS with both the number and the incidence of pressure sores. As already demonstrated by other groups [33,34], the greater the severity of the disease – also in catabolic terms – the greater the risk of pressure ulcers. Intriguingly, the extensive number of pressure injuries, even in anatomical district protected by pronation such as the sacral region, and their strong correlation with ICU LOS and MV days (intended as epiphenomena of disease severity), suggested that pronation did not play a protective effect on these minor complications' incidence. Moreover, the pathophysiological mechanism responsible for pressures injuries incidence did not seem to be simply linked to mechanical factors, such as pronation; it appeared instead to be related to a complex network of multiple mechanisms [35]. The performed propensity score analysis tends to confirm this assumption, showing no protective factor of pronation in relation to the incidence of pressure injury.

Our study presented some limitations. Firstly, it was a monocentric observational retrospective study, with a relatively small series of patients. Secondly, due to the emergency situation caused by the pandemic, it was not possible to obtain a control group; nevertheless, the evidence that major complications directly related to pronation had almost disappeared can be intended as "indirect control", suggesting that the presence of a specific team for pronation can actually reduce the rate of major complications related to this gesture. Finally, due to the retrospective nature of the study, only pressure injuries were considered among the minor complications investigated; however, among minor complications, pressure ulcers were the most important and the most represented. It can be speculated that pronation played a protective role only in complications related to a direct gesture.

Table 4
Correlation analysis between number of pressure ulcers and clinical variable in ICU.

	N sores	ICU LOS	Age	BMI	SAPS	SOFA	NEMS	MV days	Number of pronation
N sores	–	**0.467**	0.177	0.123	0.015	0.221	0.072	**0.475**	0.161
		0.001	*0.131*	*0.220*	*0.463*	*0.079*	*0.326*	***0.001***	*0.154*
ICU LOS	**0.467**	–	0.236	0.057	0.032	0.013	0.040	**0.987**	0.251
	0.001		*0.066*	*0.359*	*0.420*	*0.469*	*0.401*	***0.000***	*0.055*
Age	0.177	0.236	–	**0.309**	**0.339**	**0.344**	0.025	**0.276**	−0.201
	0.131	*0.066*		***0.023***	***0.014***	***0.013***	*0.438*	***0.039***	*0.101*
BMI	0.123	0.057	**0.309**	–	0.190	0.132	0.074	0.052	0.186
	0.220	*0.359*	***0.023***		*0.114*	*0.202*	*0.322*	*0.372*	*0.119*
SAPS	0.015	0.032	**0.339**	0.190	–	**0.319**	0.161	0.107	−0.008
	0.463	*0.420*	***0.014***	*0.114*		***0.020***	*0.154*	*0.249*	*0.481*
SOFA	0.221	0.013	**0.344**	0.132	**0.319**	**-**	**0.536**	0.068	0.036
	0.079	*0.469*	***0.013***	*0.202*	***0.020***		***0.000***	*0.334*	*0.412*
NEMS	0.072	0.040	0.025	0.074	0.161	**0.536**	–	0.055	**0.341**
	0.326	*0.401*	*0.438*	*0.322*	*0.154*	***0.000***		*0.365*	***0.013***
MV days	**0.475**	**0.987**	**0.276**	0.052 *0.372*	0.107	0.036	0.341	–	**0.264**
	0.001	***0.000***	***0.039***		*0.249*	*0.334*	*0.365*		***0.046***
Number of pronation	0.161	0.251	0.201	0.186	0.008	0.036	**0.341**	**0.264**	–
	0.154	*0.055*	*0.101*	*0.119*	*0.481*	*0.412*	***0.013***	***0.046***	

Correlation analysis. Data reported are the Pearson Correlation and p value (italic).

5. Conclusion

To improve the management of critically ill COVID-19 ICU patients in this pandemic context, the presence of a dedicated pronation team involves an amelioration in the pronation gesture, resulting in a very low rate of pronation-induced major complications. On the other side, the incidence of minor complications (pressure injuries) appeared to be related to COVID-19 severity, without a clear association with pronation, suggesting a combination of multiple pathogenic mechanisms at its basis.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal upon request.

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Declaration of competing interest

The authors declare that they have no conflict of interest for this article.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amsu.2021.102836.

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Ethical approval

This study has been notified to the Ethics Committees (Comitato Etico Cantonale, Chairman Prof. Zanini CE_TI 3763), and it has been approved in agreement to the local Federal rules. Informed consent was obtained from patients involved in the analysis.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Author contribution

Andrea Glotta: Formal analysis and Data curation; Nicola Faldarini: Conceptualization and Data curation; Maira Biggiogero: Roles/writing - original draft and Writing - review & editing; Diana Olivieri: Conceptualization and Data curation; Claudia Molteni: Conceptualization and Data curation; Stefano Petazzi: Conceptualization and Data curation; Romano Mauri: Writing - review & editing; Xavier Capdevila: Writing - review & editing; Samuele Ceruti: Conceptualization, Methodology, Roles/writing - original draft and Writing - review & editing.

Registration of research studies

1. Name of the registry: NA
2. Unique Identifying number or registration ID: NA
3. Hyperlink to your specific registration (must be publicly accessible and will be checked): NA

Guarantor

Samuele Ceruti MD.

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