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Postoperative assessment of nosocomial transmission of COVID-19 after robotic surgical procedures during the pandemic

Thomas Tabourin^{a,#}, Judith Sarfati^{b,#}, Ugo Pinar, M.D.^a, Nicolas Beaud^a, Jérôme Parra, M.D.^c, Christophe Vaessen, M.D.^c, Florie Gomez, M.D.^b, Daniel Benamran, M.D.^d, Geoffroy Canlorbe, M.D., Ph.D.^e, Jérémie Belghiti, M.D.^e, Emmanuel Chartier-Kastler, M.D., Ph.D.^c, Olivier Cussenot, M.D., Ph.D.^b, Thomas Seisen, M.D., Ph.D.^a, Morgan Roupret, M.D., Ph.D.^{a,*}

^a Sorbonne University, GRC n 5, Predictive Onco-Urology, APHP, Hôpital Pitié-Salpêtrière, Urology, Paris, France

^b Sorbonne Université, GRC n 5, Predictive Onco-Urology, APHP, Hôpital Tenon, Urology, Paris, France

^c Sorbonne University, APHP, Hôpital Pitié-Salpêtrière, Department of Urology, Paris, France

^d Division of Urology, Geneva University Hospitals, Geneva, Switzerland

^e Sorbonne University, APHP, Hôpital Pitié-Salpêtrière, Department of Surgical Gynaecology, Paris, France

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ABSTRACT

Objectives: To assess potential nosocomial coronavirus disease-2019 (COVID-19) transmission in patients who underwent robot-assisted laparoscopic procedures during the pandemic.

Material and methods: Prospective study in patients undergoing robot-assisted laparoscopy in urology or gynaecology within 2 academic hospitals. Patients underwent local preoperative COVID-19 screening using a symptoms questionnaire. Patients with suspicious screening underwent coronavirus real time-polymerase chain reaction (RT-PCR) and were excluded from robotic surgery if positive. Patients with symptoms postsurgery were systematically tested for coronavirus by RT-PCR. One-month postsurgery, all patients had a telephone consultation to evaluate COVID-19 symptoms.

Results: Sixty-eight patients underwent robotic surgery during the study period (median age: 63-years [IQR: 53–70], 1.8 male: female ratio). Oncology was the main indication for robotic surgery ($n = 62$, 91.2%) and 26 patients (38.2%) received a chest CT-scan prior to surgery. Eleven patients (16.2%) were symptomatic after surgery of whom only 1 tested positive for coronavirus by RT-PCR (1.5%) and was transferred to COVID-19 unit with no life-threatening condition. No attending surgeon was diagnosed with COVID-19 during the study.

Conclusions: Robot-assisted laparoscopic surgery seemed safe in the era of COVID-19 as long as all recommended precautions are followed. The rate of nosocomial COVID-19 transmission was extremely low despite the fact that we only used RT-PCR testing in symptomatic patients during the preoperative work-up. Larger cohort is needed to validate these results. © 2020 Elsevier Inc. All rights reserved.

Keywords: SARS-CoV-2; Communicable disease; Surgery; Coronavirus; COVID-19; Robotics; Nosocomial transmission; Urology; Gynaecology

1. Introduction

Starting in the Wuhan region of China in December 2019, coronavirus disease-2019 (COVID-19), caused by the virus SARS-CoV-2, has spread worldwide and was declared a

pandemic by the World Health Organisation on 11th March, 2020. COVID-19 has currently been detected in more than 200 countries and has caused more than 200,000 deaths worldwide [1]. In order to reduce virus spilling, social distancing and hygienic protective measures were rapidly introduced, especially in hospitals. This has led to a major challenge for physicians to maintain optimal healthcare access for patients while ensuring a low transmission risk for both healthcare workers and patients. Such a consideration is particularly

[#]The first two authors contributed equally to this paper.

*Corresponding author. Tel.: +33142177297; fax: +33142177295.

E-mail address: morgan.roupret@aphp.fr (M. Roupret).

relevant for the management of urogynaecological cancers, given that surgical removal of these tumours cannot be delayed for too long [2,3].

While the use of robotic surgery has dramatically increased in urology and gynaecology over the past 2 decades, it involves work in an environment employing gas. Importantly, the use of a gas insufflator to create a pneumoperitoneum is considered to have the same effect as an aerosol and this could result in an increased risk of COVID-19 transmission during these surgical procedures. Although no specific data are currently available on this subject, some precautionary measures have been promoted by different scientific societies in order to minimise the theoretical risk of nosocomial COVID-19 dissemination [4,5]. Similarly, it has been suggested that hospital stay for surgery could represent an important risk factor for COVID-19 infection by promoting contact with positive cases. Nevertheless, the role of surgery overall, especially surgery using a robotic approach, in nosocomial COVID-19 dissemination remains unclear.

Our aim was to assess the nosocomial transmission of COVID-19 among urogynaecological patients who underwent robotic surgery during the pandemic.

2. Patients and Methods

2.1. Study population and data collection

All patients who underwent robotic surgery for any urogynaecological condition during the COVID-19 pandemic at 2 academic hospitals in Paris, France, were considered for the present study. Cases operated on between the start of pandemic stage 3 (i.e., “sanitary crisis”) in France on March 2nd, 2020, and April 14th, 2020, were selected in order to have a 1 month delay for analyses, in line with the theoretical incubation period for COVID-19 [6]. Patients who had a positive preoperative COVID-19 status and who did not undergo local screening were excluded from the study.

All patients were screened systematically for COVID-19 symptoms prior to surgery using a standardized questionnaire in both centres. The questionnaire was created urgently and validated by the local crisis committee of the Assistance

Publique des Hôpitaux de Paris. This questionnaire allowed us to look for previously described symptoms of COVID-19 such as fever, flu-like syndrome, anosmia or digestive symptoms, as well as previous contact with COVID-19 cases (Table 1). Moreover, each patient had a forehead temperature check at the time of hospitalisation. Patients with any positive item listed in the questionnaire 72- or 24-hours before surgery and/or positive CT-chest imaging at admission to 1 of the 2 centres were considered as suspected cases and underwent nasopharyngeal swabs for coronavirus real time-polymerase chain reaction (RT-PCR).

Robotic surgery was postponed for 2 patients with positive RT-PCR who were excluded from the present study, while those with negative RT-PCR were hospitalized in single rooms in a COVID-19 negative unit and considered for further analysis. The following data were collected for all included patients: gender, age, surgical indication, operative time, blood loss, blood transfusion, length of hospital stay, postoperative complications and surgical report.

2.2. Robotic surgery and healthcare workers

All robotic procedures were performed using an Xi Intuitive system, following precautionary recommendations [4,5]. A pneumoperitoneum was generated using a 1-way insufflator with an intelligent integrated flow system (Air-Seal system) configured in continuous smoke evacuation and filtration mode. The system was unique and was renewed for each patient. Surgery was performed with the lowest possible intra-abdominal pressure. Disinflation was carried out using the integrated active smoke evacuation mode. Patient intubation was performed when the surgical team was outside the operating theatre. Ventilation filters were changed between each patient.

Each member of the surgical and anaesthetic team wore adequate protective equipment including glasses, Filtering Facepiece Particles 2 masks and body protective overalls. No COVID-19 infection was diagnosed among the healthcare workers who managed the included patients (surgical, anaesthetic, and nursing teams) over the study period.

2.3. Postoperative screening and follow-up

Postoperative assessment of COVID-19 symptoms was performed systematically during hospitalization. After discharge, patients were instructed to return to the hospital for retesting for coronavirus by RT-PCR if any specific symptom developed. In addition, all patients were called by telephone 1 month after surgery by a resident to record any symptoms of COVID-19. Patients were also asked to score their fear of being infected during hospitalization and/or surgery on a Likert scale (1 = no fear, 10 = major fear).

2.4. Statistical analysis

Quantitative variables are described as median and interquartile range (IQR) and qualitative variables as numbers

Table 1
Preoperative questionnaire used for screening COVID-19 symptoms

Have you been diagnosed as COVID-positive?

Yes
 No

Have you been symptomatic but not-tested for Covid-19 in the last 15 days?

Yes
 fever cough headache flu-like syndrome
 any digestive symptom anosmia
 No

Have you been in contact with a symptomatic person?

Yes
 No

Translated into English from the questionnaire available at: www.aphp.fr.

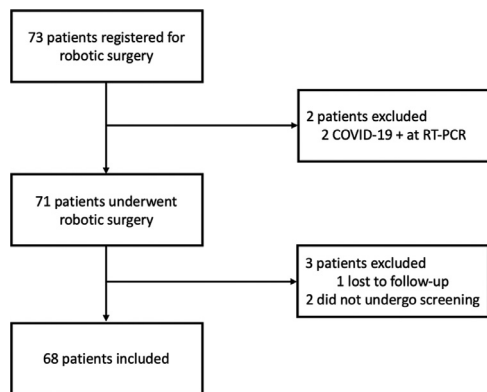


Fig. 1. Flow chart.

and percentage. All statistical analyses were performed using R version 3.6.2. (2009–2019 RStudio, Inc.).

3. Results

3.1. Study population

Overall, 68 patients without any suspicion of COVID-19 underwent robotic surgery during the study period (Fig. 1). Median age was 63 years (IQR: 53–70) and sex-ratio was 1.8 (male: female) (Table 2). Prior to surgery, 26 patients (38.2%) received a chest CT-scan that were all negative for COVID-19 radiological signs. Among the patients' relatives, no-one had a confirmed COVID-19 positive status.

Of the 68 robotic surgeries, 56 (82.4%) and 12 (17.6%) were performed for urological and gynaecological

Table 2
Demographic characteristics of the study population

Characteristic	Total cohort (N = 68)
Age (years), median [IQR]	63 [53–70]
Gender, n (%)	
Female	24 (35.3)
Male	44 (64.7)
Reason for surgery, n (%)	
Infection	3 (4.4)
Functional	3 (4.4)
Oncology	62 (91.2)
Type of surgery, n (%)	
Radical prostatectomy	25 (36.7)
Partial nephrectomy	11 (16.2)
Total nephrectomy	9 (13.2)
Cystectomy	4 (5.8)
Nephroureterectomy	5 (7.4)
Prostate adenectomy	1 (1.5)
Pyeloplasty	1 (1.5)
Sacro colpopexy	1 (1.5)
Hysterectomy	10 (14.7)
Ovariectomy	1 (1.5)
COVID-19 status, n (%)	
Suspected	4 (5.9)
Confirmed	0 (0)
No symptoms	64 (94.1)

Table 3
Surgical outcomes

	Total cohort (N = 68)
Operative time (min), median [IQR]	162 [142–225]
Peroperative blood transfusion, n (%)	3 (4.4)
Dindo-Clavien score, n (%) ^a	
Grade I	1 (1.5)
Grade II	2 (2.9)
Grade III	1 (1.5)
Grade IV	2 (2.9)
Grade V	0 (0)
Postoperative complications, n (%) ^a	
Haematoma	2 (2.9)
Urinary infection	2 (2.9)
Evisceration	1 (1.5)
Digestive leak	1 (1.5)
Length of hospitalization (days), median [IQR]	4 [3–5]
1-month complications, n (%)	1 (1.5)
Neutropenia	1 (1.5)

^a During hospitalization.

conditions, respectively (Table 2). Cancer cases represented most of the indications for robotic surgery (n = 62, 91.2%), including 25 radical prostatectomies (36.7%), 10 hysterectomies (14.7%), 11 partial nephrectomies (16.2%), 6 radical nephrectomies (8.8%), 5 nephroureterectomies (7.4%), 4 cystectomies (5.8%) and 1 ovariectomy (1.5%) (Table 2). There were 3 nephrectomies for chronic infections (4.4%).

3.2. Surgical outcomes

Median operative time was 162 minutes (IQR: 142–225) and 3 patients (4.4%) underwent per-operative blood transfusion (Table 3). There were 6 surgical complications (8.8%) during hospitalization: 2 haematomas (2.9%), 2 urinary tract infections (2.9%), 1 evisceration (1.5%), and 1 digestive leak (1.5%). Median length of stay was 4 days (IQR: 3–5). Only 1 patient had a complication within 1-month postsurgery (neutropenia in a patient treated for myeloma).

3.3. Postoperative COVID-19 status

Overall, 11 patients (16.2%) had COVID-19 symptoms postsurgery (Table 4). Among these patients, 1 tested positive for COVID-19 (1.5%) and 10 tested negative (14.7%). None of these 10 patients was re-admitted to hospital.

The patient with COVID-19 was a 78-year-old woman who tested positive during hospitalization, 5 days after radical nephroureterectomy for upper tract urothelial carcinoma. She complained of fever (maximum temperature was 38.3°C) associated with flu-like syndrome since post-operative day 3. Haematological investigations revealed mild lymphopenia (minimum 1.07 g/l) and anaemia (7.7 g/dl). None of the patient's relatives was symptomatic or tested positive before the onset of her symptoms. With regards to management, she was isolated and transferred

Table 4
Postoperative COVID-19 status

COVID-19 status	Total cohort (N = 68)
Symptomatic patients	11 (16.2)
Negative RT-PCR	10 (14.7)
Positive RT-PCR	1 (1.5)
Symptoms details among RT-PCR-negative patients	
Cough	3 (30)
Fever	5 (50)
Influenza like syndrome	0 (0)
Anosmia	2 (20)

All values shown are *n* (%).

to a dedicated COVID-19 unit. She did not develop a life-threatening condition and did not need supplementary oxygen. The patient was finally discharged from hospital 2 days after the positive diagnosis of a mild COVID-19 illness.

3.4. Anxiety

The fear of being infected by coronavirus during hospitalization or surgery was expressed with a median score of 5 out of 10 (IQR: 2–7). Overall, 26 (38.2%), 22 (32.4%), and 20 (29.4%) patients expressed a mild (0–3), moderate (4–6), and major (>6) fear of being infected, respectively.

4. Discussion

The theoretical risk of coronavirus infection during hospitalization and/or surgery was mentioned at the start of the outbreak, resulting in a dramatic decrease in surgical volume, especially for robotic procedures in some centres. Since then, safety recommendations and guidance from scientific associations has emerged and almost all nonurgent surgical robotic procedures were postponed in line with French national guidelines [7], given that COVID-19 can easily be transmitted from person to person through small respiratory droplets or direct contact with contaminated surfaces [8,9]. In parallel, a lot of resources from the operating room have been reallocated to intensive care units (ICUs) for the management of severe COVID-19 patients. Thus, the daily practice of surgeons has had to be adapted and flexible, but reductions in surgical volume of >60% have been observed in academic hospitals in Paris [10].

At the moment of this study, in our departments we did not have routinely access to SAR-Cov2 tests, this is the main reason why all patients did not undergo RT-PCR pre-operative screening. Indeed, we were limited by the daily test available that were used only for suspicious patients. Our capacity to perform test in France increased at the middle of the month of April. From the end of April, when enough tests were available in France, it has been recommended to perform a test for SARS-Cov 2 48 hours prior to any surgery.

In this study, only 1 (1.5%) female patient developed a minor form of COVID-19 out of 68 individuals who underwent robotic surgery for urogynaecological conditions. This is an oncological procedure for which the risk of COVID-19 transmission has to be weighed against the risk of cancer progression. In these patients, the cure is unlikely to be worse than the disease. This isolated event demonstrates the safety of robotic surgery with regards to the post-operative risk of COVID-19 and robotic surgery should not be considered as a risk factor for nosocomial COVID-19. In addition, 1 key point of our study is that our only nosocomial COVID-19 patient did not develop a life-threatening condition requiring oxygen or admission to an ICU.

The possibility of nosocomial COVID-19 transmission has become a sad reality and hospital management has had to adapt day-by-day by editing guidance based on pandemic knowledge and behaviour [11]. Various studies have demonstrated that elderly patients in ICUs are more likely to acquire nosocomial COVID-19 [12,13]. However, nosocomial COVID-19 transmission has been poorly evaluated postoperatively [14] and our study represents one of the largest reports on the specific risk of nosocomial COVID-19 after robotic surgery for urogynaecological conditions.

With regards to the risk of COVID-19 transmission through the pneumoperitoneum during robotic procedures, previous reports have already warned about the risk of transmission of viral particles by surgical smoke [15,16]. Moreover, human papilloma virus transmission has been shown to be higher during laparoscopic surgical procedures [17]. A pneumoperitoneum is obtained by high pressure insufflation in the abdominal cavity with low mobility forming aerosols with human bodily fluids. Given that many of these bodily fluids, including urine, blood, and faeces [18,19], have been shown to contain SARS-CoV-2, it is also likely that this virus can be found in peritoneal secretions. Although the possibility of oro-faecal transmission is still unknown, contamination via urine or blood seems possible [20–22] and it could be the same for peritoneal secretions. However, we believe that the systematic use of the Airseal system for all of our procedures with a unique filtration system for insufflated air was a great tool to avoid massive contamination with the virus during our robotic procedures. This was done in accordance with the crisis recommendations provided by the ERUS and other urological societies to drastically reduce the transmission risk [23].

With regards to the risk of COVID-19 transmission during the hospital stay, we observed that the use of a robotic approach was associated with a shorter length of stay. This may have resulted in a decreased risk of nosocomial COVID-19 transmission when compared to open procedures. Several reports have shown that robotic procedures were associated with a shorter length of stay than open surgery.

Importantly, almost all of the patients included in our study underwent robotic procedures for urogynaecological cancers. Following the lockdown in France on March 17th, 2020, many surgeries considered as non-urgent were

cancelled or delayed, even in the field of oncology. As a consequence, we are facing an imminent oncological healthcare crisis that could be exacerbated if patients fear nosocomial infection [24]. It is our duty to comfort patients by providing COVID-19-free procedures and ensure that the best protective measures are used in order to maintain healthcare access for all. Our study is along these lines and should reassure both patients and surgeons.

Our study has several limitations. Its small sample size could bias our results and prevent us to draw definite conclusions. It could be argued that the preoperative protocol was far from perfect and that even patients without symptoms should have been tested for coronavirus. In addition, the predictive value of chest-CT scans in asymptomatic patients with COVID-19 has not been demonstrated. It should be remembered that all these procedures were decided in an emergency situation with no clear guidance from colleagues from other areas of the world where the virus had already hit (e.g., China, Italy). In addition, previous reports have shown that the sensitivity of tests for coronavirus is low, with a maximum sensitivity of 83% [25]. As a consequence, we may have missed positive asymptomatic patients or had negative tests in both the preoperative and postoperative settings. We also cannot exclude detection bias in the case where patients misanswered initial screening survey. Finally, rapidly evolving practice such as generalization of SARS-Cov 2 RT-PCR may limit the generalizability of these findings, especially regarding protective equipment used during surgery.

In conclusion, in the light of our data, we believe that performing robotic surgery during the COVID-19 pandemic does not seem to be a risk factor for nosocomial COVID-19 transmission. However, given that the pandemic crisis is likely to last, we should define the optimal preoperative protocol in order to provide the safest environment for our patients and surgical teams. These results will need an external validation within a bigger cohort.

Conflict of interest

The authors declare no conflict of interest or funding in relation to this study.

References

- [1] Coronavirus. Available at: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019>. Accessed April 19, 2020.
- [2] Russell B, Liedberg F, Khan MS, et al. A systematic review and meta-analysis of delay in radical cystectomy and the effect on survival in bladder cancer patients. *Eur Urol Oncol* 2020;3:239–49.
- [3] Professionals S-O. COVID-19 recommendations. Uroweb. Available at: <https://uroweb.org/guideline/covid-19-recommendations/>. Accessed May 4, 2020.
- [4] Resources for smoke & gas evacuation during open, laparoscopic, and endoscopic procedures. SAGES 2020: Available at: <https://www.sages.org/resources-smoke-gas-evacuation-during-open-laparoscopic-endoscopic-procedures/>. Accessed May 5, 2020.
- [5] Professionals S-O. EAU robotic urology section (ERUS) guidelines during COVID-19 emergency. Uroweb 2020: Available at: <https://uroweb.org/eau-robotic-urology-section-erus-guidelines-during-covid-19-emergency/>. Accessed Apr 19, 2020.
- [6] Guan W, Ni Z, Hu Y, et al. Clinical characteristics of 2019 novel coronavirus infection in China. medRxiv 2020. <https://doi.org/10.1101/2020.02.06.20020974>.
- [7] Méjean A, Roupêt M, Rozet F, et al. Recommendations CCAFU on the management of cancers of the urogenital system during an epidemic with Coronavirus COVID-19 [Article in French]. *Prog Urol* 2020;30:221–31.
- [8] Liu Y, Eggo RM, Kucharski AJ. Secondary attack rate and super-spreading events for SARS-CoV-2. *Lancet* 2020;395:e47.
- [9] Rothan HA, Byrareddy SN. The epidemiology and pathogenesis of coronavirus disease (COVID-19) outbreak. *J Autoimmun* 2020;109:102433.
- [10] Pinar U, Anract J, Duquesne I, et al. Impact of the COVID-19 pandemic on surgical activity within academic urological departments in Paris. *Prog en Urol* 2020. <https://doi.org/10.1016/j.purol.2020.05.001>.
- [11] Wang J, Zhou M, Liu F. Reasons for healthcare workers becoming infected with novel coronavirus disease 2019 (COVID-19) in China. *J Hosp Infect* 2020;105:100–1.
- [12] Vanhems P. Fast nosocomial spread of SARS-CoV2 in a French geriatric unit Lyon Study Group on Covid-19 infection. *Infect Control Hosp Epidemiol* 2020;1:1–4.
- [13] Phua J, Weng L, Ling L, et al. Intensive care management of coronavirus disease 2019 (COVID-19): challenges and recommendations. *Lancet Respir Med* 2020;8:506–17.
- [14] Luong-Nguyen M, Hermand H, Abdalla S, et al. Infection nosocomiale à SARS-Cov-2 dans les services de chirurgie digestive. *J Chir Viscerale* 2020. <https://doi.org/10.1016/j.jchirv.2020.04.012>.
- [15] Kwak HD, Kim S-H, Seo YS, Song K-J. Detecting hepatitis B virus in surgical smoke emitted during laparoscopic surgery. *Occup Environ Med* 2016;73:857–63.
- [16] Sawchuk WS, Weber PJ, Lowy DR, Dzubow LM. Infectious papillomavirus in the vapor of warts treated with carbon dioxide laser or electrocoagulation: detection and protection. *J Am Acad Dermatol* 1989;21:41–9.
- [17] Zheng MH, Boni L, Fingerhut A. Minimally invasive surgery and the novel coronavirus outbreak: lessons learned in China and Italy. *Ann Surg* 2020. <https://doi.org/10.1097/SLA.0000000000003924>.
- [18] Peng L, Liu J, Xu W, et al. SARS-CoV-2 can be detected in urine, blood, anal swabs and oropharyngeal swabs specimens. *J Med Virol* 2020. <https://doi.org/10.1002/jmv.25936>.
- [19] Ling Y, Xu S-B, Lin Y-X, et al. Persistence and clearance of viral RNA in 2019 novel coronavirus disease rehabilitation patients. *Chin Med J (Engl)* 2020;133:1039–43.
- [20] Yeo C, Kaushal S, Yeo D. Enteric involvement of coronaviruses: is faecal-oral transmission of SARS-CoV-2 possible? *Lancet Gastroenterol Hepatol* 2020;5:335–7.
- [21] Chen W, Lan Y, Yuan X, et al. Detectable 2019-nCoV viral RNA in blood is a strong indicator for the further clinical severity. *Emerg Microbes Infect* 2020;9:469–73.
- [22] Chang L, Yan Y, Wang L. Coronavirus disease 2019: coronaviruses and blood safety. *Transfus Med Rev* 2020. <https://doi.org/10.1016/j.tmr.2020.02.003>.
- [23] Puliatti S, Eissa A, Eissa R, et al. COVID-19 and Urology: a comprehensive review of the literature. *BJU Int* 2020. <https://doi.org/10.1111/bju.15071>.
- [24] Oderda M, Roupêt M, Marra G, et al. The impact of COVID-19 outbreak on uro-oncological practice across Europe: which burden of activity are we facing ahead? *Eur Urol* 2020. <https://doi.org/10.1016/j.eururo.2020.04.036>.
- [25] Kokkinakis I, Selby K, Favrat B, Genton B, Cornuz J. [Covid-19 diagnosis: clinical recommendations and performance of nasopharyngeal swab-PCR] [Article in French]. *Rev Med Suisse* 2020;16:699–701.