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Short Communication

Diagnosis of SARS-CoV-2 infection from breath - a proof-of-concept study

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ABSTRACT

Bioaerosol capture and analysis is emerging as a non-invasive diagnostic method for the detection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). In this proof-of-concept study conducted in Lesotho, we evaluated the novel and simple AL2 bioaerosol detection device in comparison to conventional nasopharyngeal sampling methods. We demonstrated for the first time that SARS-CoV-2 can be detected using the AL2 bioaerosol capture device. However, studies with a larger sample size are needed to further evaluate this bioaerosol capture device for the detection of SARS-CoV-2.

Introduction

Bioaerosol capture and analysis has the potential to become a non-invasive diagnostic method for the detection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Riccò et al., 2022) and other respiratory pathogens that are transmitted through respiratory droplets and aerosol particles (Drossinos et al., 2021, Jayaweera et al., 2020). While tests from nasopharyngeal or nasal mucosal swabs may be negative at an initial, already infectious stage of infection, bioaerosol-based tests might allow more timely detection, treatment and isolation of infectious patients (Hawks et al., 2021, Jarvis and Kelley, 2021, Kucirka et al., 2020, Ma et al., 2021). We conducted a study in Lesotho evaluating a novel bioaerosol collection device in comparison to conventional nasopharyngeal sampling methods to investigate whether SARS-CoV-2 can be detected using this device.

Methods

This study took place during two waves of the COVID-19 pandemic (study periods: Sep 8-23, 2021 and Jan 6 – Feb 3, 2022) at St. Charles Mission Hospital Seboche, Lesotho. Surveillance data from South Africa, Lesotho's neighbour, strongly suggest that the Delta variant was predominant during the first study period and the Omicron variant during the second (Viana et al., 2022).

Persons aged ≥18 years with body temperature ≥38°C or at least one of 10 symptoms (fever/chills, cough, tiredness, dyspnea, sore throat, body pain, diarrhea, loss of taste/smell, recent weight loss, night sweats) or close contact to a probable or confirmed COVID-19 case in the last 14 days were eligible.

A novel bioaerosol capture device (Reconogen™; AL2 Impact, Inc, US), consisting of a blow tube containing a removable capture disc made of inert polymers, served as an index test. With the device pressed against the mouth or nostril, participants performed 20 deep breaths, 10 coughs, and a count to 20 and 10 exhalations through each nostril while closing the opposite nostril. Thereafter, the capture disc was pushed into a vial with 1mL Universal Transport Medium buffer, Triton X-45 was added (only in first study period), vortexed and real-time SARS-CoV-2 PCR (Alinity m System, Abbott, USA) was performed.

As a reference standard, real-time SARS-CoV-2 PCR (SARS-CoV-2/2019-nCoV assay by Daan Gene /ABI 7500 platform (target: N gene and ORF1ab), Applied Biosystems, USA, first study period; Alinity m System (target: N gene and RdRp), Abbott, USA, second study period; Limit of detection: Daan Gene assay: 500 virus copies/ml; Alinity *m* assay: 100 virus copies/ml) was done from a nasopharyngeal swab (NP-PCR). Comparator was an antigen rapid diagnostic test (STANDARD Q

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Table 1
Overview of performance results in both study periods.

Bioaerosol capture device (PCR)	NP-RDT	NP-PCR	First study period	Second study period	Total
positive	**positive**	**positive**	3	7	10
positive	**positive**	negative	3	0	3
positive	negative	**positive**	0	3	3
positive	negative	negative	3	0	3
negative	**positive**	**positive**	2	1	3
negative	**positive**	negative	1	0	1
negative	negative	**positive**	0	21	21
negative	negative	negative	43	44	87

Table 2
Performance results in relation to time from symptom onset in both study periods. N=44 had at least one positive test but 1 of these was missing information on the time since onset of symptoms.

Days from symptom onset	Patients tested positive by any test	Bioaerosol-positive patients	NP-RDT-positive patients	NP-PCR-positive patients
0-3	8	5 (62.5%)	3 (37.5%)	6 (75.0%)
4-7	20	9 (45.0%)	8 (40.0%)	17 (85.0%)
8-14	8	4 (50.0%)	4 (50.0%)	7 (87.5%)
≥15	7	1 (14.3%)	1 (14.3%)	6 (85.7%)

COVID-19 Ag Test, SD Biosensor, Republic of Korea) from a second nasopharyngeal swab (NP-RDT). Patients were asked to blow their nose before the nasopharyngeal swab.

Results

The median age of the 131 participants was 46 years (IQR 33-62), 63.4% (83) were female, 96.2% (126) had at least one symptom, and 3.1% (4) COVID-19 exposure only. None of the participants were severely ill (i.e. altered mental status, tachypnea, SpO2<94%, or systolic blood pressure <100mmHg).

Test performance during the first study period

During this period, we recruited 55 participants. The bioaerosol capture device showed positive results in 9 participants, with 3 of these participants being NP-PCR-negative and NP-RDT-positive, and 3 being both NP-PCR- and NP-RDT-negative (Table 1). Overall, only 5 participants had a positive NP-PCR (positivity rate 9.1%). Using NP-PCR as reference standard (as per protocol), the sensitivity of the bioaerosol capture device is 60.0% (95%CI: 14.7-94.7) and the specificity is 88.0% (95%CI: 75.7-95.5).

Test performance during the second study period

During this period, we recruited 76 participants; 32 had a positive NP-PCR (positivity rate 42.1%), 10 participants had a positive result from the bioaerosol capture device, of which 7 matched the total of 8 positive NP-RDT results (Table 1). With NP- PCR as a reference standard (as per protocol), the sensitivity and the specificity of PCR from bioaerosol capture device is 31.3% (95%CI: 16.1-50.0) and 100.0% (95%CI: 92.0-100.0).

The performance results in relation to time from symptom onset in both study periods is shown in Table 2.

Discussion

In this study, we provided evidence that SARS-CoV-2 can be detected with the AL2 bioaerosol capture device. Of note, the bioaerosol capture device identified 6 patients during the first study period who were not identified by NP-PCR, suggesting that negative NP-PCR results do not always rule out SARS-CoV-2 infection and it is a potentially imperfect reference standard (Mardian et al., 2021). Due to the small sample size, generalizable conclusions about diagnostic performance and relationship to other variables (symptom duration, Ct or CN score) or a recommendation for clinical use cannot be made at this time, and further studies with a larger sample size are needed to evaluate this bioaerosol capture device for SARS-CoV-2 detection.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. AL2 Impact and 3M Company provided the bioaerosol capture devices and gave technical advice, but were not involved in data analysis.

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Ethical Approval statement

The National Research and Ethics Committee of Lesotho (ID-107-2020 Modify 03) approved the study. All participants provided written informed consent.

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