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Needle-to-Incubator Transport Time: Logistic Factors Influencing Transport Time for Blood Culture Specimens[▽]

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The maximum recommended transport time for blood cultures is 4 h [L. S. Garcia (ed.), *2007 Update: Clinical Microbiology Procedures Handbook*, 2nd ed., 2007]. In a previous study, we found that the average transport time was 10 h. In this cohort study, we measured transport times for blood cultures in a larger sample and identified predictors for transport times. A total of 4,322 blood cultures from 1,313 patients were included. The median transport time was 3.5 h, with 47% of cultures exceeding the recommended 4 h. Off-site location and type of clinical specialty were the most important predictors of long transport times. Cultures collected during weekend days or on wards at the largest distances from the laboratory were also associated with long transport times.

Patient care can be improved by timely results of positive blood cultures. Byl et al. (2) showed that with the availability of blood culture results, the proportion of appropriate treatments increased from 63 to 94%. Adjustment of antibiotic treatment according to the results of blood cultures also leads to decreased antibiotic use and costs (1). Most efforts have been focused on developing rapid diagnostic testing techniques. However, little is known about the seemingly simple but basic logistic principles that determine the transport to the laboratory.

We previously found an average transport time for blood culture specimens of 10.4 h (4), which is much longer than the maximum recommended time of 4 h (3). The aim of the present cohort study was to measure transport times for blood cultures and to identify predictors of these transport times.

The Erasmus University Medical Centre is a 1,200-bed tertiary-care university medical center; it has a medical microbiological laboratory that is open on weekdays from 7:30 a.m. until 5:00 p.m., and on Saturdays and Sundays from 8:30 a.m. until 1:00 p.m. A blood culture incubator (Bactec 9120; Becton Dickinson, Sparks, MD) is located outside the laboratory to enable the direct incubation of blood culture bottles outside of the laboratory's open hours. The laboratory receives blood cultures from 66 clinical wards, of which 53 are located in the main building where the laboratory is situated and 13 are located outside of the main building in another part of the city (off-site wards). The laboratory staff pick up and transport blood culture bottles from 44 (on-site) wards to the laboratory during rounds scheduled at 8:30 a.m., 11:00 a.m., 1:30 p.m., or 2:00 p.m. In total, 23 wards are visited once daily, 20 twice daily, and 1 (the on-site hematology ward) is visited three times a day. After these collection times have passed, ward personnel are instructed to bring the cultures to the laboratory themselves. From wards that are not visited, specimens are transported by a courier service (off-site wards) or by their own personnel (the on-site wards). For this study, the 66 clinical wards were grouped into 13 clinical specialties.

All blood cultures for which time-of-culture sampling and arrival time at the laboratory were recorded were included in this study. For each specimen, data on the microbiological culture results were collected; and for each patient, the ages and the departments of stay during the drawing of the blood cultures were collected from the hospital information system. Walking distances from the wards to the laboratory were measured during daytime and evening hours. Both measurements were averaged. The time of bottle entry into the Bactec incubator outside the laboratory was registered automatically outside of the open hours. During open hours, the arrival time of the blood culture at the laboratory was registered.

Median laboratory transport times and the interquartile range (IQR) were calculated per the clinical specialty group. To determine predictors associated with laboratory transport time, we used univariate and multivariate Cox proportional hazards models including the following variables: patient's age, walking distance from the ward to the laboratory, number of daily rounds at the wards to collect the cultures, time of culture collection before a daily round, collection during the laboratory's open hours, collection during weekdays or weekend days, clinical specialty, and bacterial culture growth. A variable with a hazard ratio (HR) of >1 is associated with a shorter transport time, and a variable with a HR of <1 is associated

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TABLE 1. Median laboratory transport times from collection until arrival for blood cultures, by clinical specialty and location of wards, in a Dutch university medical center

Clinical specialty	No. of clinical wards	No. of off-site wards	No. of daily rounds[a]	Minimum-maximum two-way walking time (min)[a]	No. of blood cultures analyzed	Median laboratory transport time [IQR in h (range)]
Neurology	2	0	1–2	3.5–36	65	0.60 (0.38–1.41)
Nephrology	1	0	2	1.3	212	0.87 (0.38–1.97)
General internal medicine	3	0	1	1.3–2.1	131	1.17 (0.53–3.93)
Surgery	12	0	1–2	2.7–5.7	411	1.30 (0.53–3.49)
Gastroenterology	1	0	2	2.3	173	1.33 (0.48–2.94)
Infectious disease	2	0	2	3.2	293	1.90 (0.73–4.37)
Other (outpatient, psychiatry, and revalidation)	20	3	0–2	4.3–4.4	67	2.00 (0.81–3.20)[c]
Thorax center[b]	5	0	1–2	4.9–7.9	193	2.65 (1.22–5.75)
Pulmonology	2	0	1	4.7	44	3.08 (0.83–14.20)
ICU	3	0	1–2	2.3–5.7	818	3.54 (2.12–11.90)
Thorax center ICU[b]	2	0	2	6.8–6.9	241	3.87 (1.83–8.47)
Hematology/oncology	12	10	1–3	1.3–4.3	1,450	12.63 (3.06–16.36)[d]
ER	1	0	1	5.1	224	16.00 (9.70–19.07)
Total	66	13	0–3	1.3–7.9	4,322	3.52 (1.33–13.90)

[a] Not applicable for off-site departments.
[b] Combined wards of cardiology and thoracic surgery, located in a separate building but connected with the main hospital building.
[c] On-site, 1.56 (0.78–2.65); off-site, 12.63 (9.37–13.50).
[d] On-site, 2.83 (1.39–10.82); off-site, 14.55 (4.92–17.78).

with a longer transport time. Backward selection was used to obtain a multivariate model that included significant variables only.

During 15 weeks (in the period from 24 March to 5 October 2005), 5,868 blood cultures arrived at the laboratory. Of these, 1,546 (26%) lacked information on the time of sampling. Thus, 4,322 blood cultures taken from 1,313 patients were included; their mean age was 55 years (standard deviation, 17 years). A median number of two blood cultures was collected per patient, ranging from 1 culture to 44 cultures (IQR, 1 to 3). The median time between culture collection and arrival at the laboratory was 3.5 h (IQR, 1.3 to 13.9 h). The percentage of cultures arriving within 4 h was 53.2%.

Table 1 shows the median transport time, the median time required to cover the two-way walking distance from the ward to the laboratory, and the number of daily collection rounds per clinical specialty. Median transport times for the off-site wards were substantially longer than for the on-site wards.

In univariate analysis, patient age, walking distance, number of daily rounds, time of culture collection, and medical specialty were significantly associated with blood culture transport time (Table 2). Cultures collected from persons older than 50 years, departments with a two-way walking distance within 4 min of the laboratory, and wards with twice-a-day collection rounds and specimens that were taken within 0.5 to 2 h before a daily round were associated with a shorter transport time. Cultures collected from off-site wards, the emergency room (ER), the intensive care unit (ICU), and from the on-site wards, the departments of pulmonology and hematology/oncology, as well as cultures collected during weekend days were associated with a longer transport time. In multivariate analysis, walking distance, number of collection rounds, collection during weekdays or weekend days, and clinical specialty were independently associated with transport time (Table 2). Cultures from off-site wards were associated with a longer transport time than cultures from on-site wards (HR, 0.26; 95% confidence interval [CI], 0.15 to 0.45), in comparison with cultures collected from wards within 4-min walking distances, because the courier service from off-site locations only operates during open hours. Cultures collected at wards with one or three rounds were associated with longer transport times than were cultures collected at wards with two rounds (HR of 0.85 and 95% CI of 0.75 to 0.97 compared to HR of 0.44 and 95% CI of 0.21 to 0.93). Probably due to the three visits, nurses may feel it is unnecessary to bring the blood cultures themselves.

Specimens collected at the thorax center, the departments of nephrology, infectious disease, and pulmonary disease, the ICU, the thorax center ICU, and the ER showed longer transport times than for specimens from the surgical wards. The transport delay on the ICU and ER could be due to the high workload of the nursing staff, and the delay on the ER may also be due to personnel waiting for cultures to be collected (8:30 a.m. each morning).

Growth or no growth and the kind of microorganisms grown were not predictors for transport time. Although we did not measure the seriousness of disease, these data suggest that the disease of the patient does not affect the behavior of the health care workers in the rapidity of bringing blood culture bottles to the laboratory.

The scientific aspects of blood cultures, such as selection and ingredients of media, inoculum volume, and positive signal detection methods, have been frequently investigated, but the simple logistic aspects of blood cultures, such as transportation, have rarely been studied. In an era of in-

TABLE 2. Univariate and multivariate Cox proportional hazards models for laboratory transport time for 4,322 blood cultures

Factor	Univariate model[a]	Overall *P*	Multivariate model[a]	Overall *P*
Age		0.001		
≤50 yr	1			
>50 yr	1.11 (1.04–1.18)			
Walking distance (two-way)		<0.001		<0.001
Within 4 min	1		1	
Between 4 and 8 min	0.51 (0.48–0.55)		0.80 (0.69–0.84)[c]	
Off-site wards[b]	0.30 (0.28–0.33)		0.26 (0.15–0.45)	
No. of daily rounds		<0.001		<0.001
None/off-site	0.38 (0.35–0.42)		0.64 (0.39–1.05)	
One	0.65 (0.60–0.70)		0.85 (0.75–0.97)	
Two	1		1	
Three	0.71 (0.64–0.78)		0.40 (0.28–0.56)	
Time of specimen collection before daily rounds		<0.001		
<0.5 h	1			
0.5–2 h	1.16 (1.01–1.34)			
2–4 h	1.00 (0.86–1.18)			
4–8 h	0.96 (0.83–1.11)			
>8 h	0.84 (0.75–0.94)			
Not applicable (off-site or no daily rounds)	0.44 (0.39–0.50)			
Collection during laboratory's open hours (7:30 a.m.-4:30 p.m.)		1.24		
Yes	1			
No	0.95 (0.90–1.01)			
Collection day		<0.001		0.017
Weekdays	1		1	
Weekend days	0.87 (0.81–0.94)		0.92 (0.85–0.98)	
Medical specialty		<0.001		<0.001
Surgery	1		1	
Thorax center[d]	0.74 (0.63–0.88)		0.80 (0.65–0.98)	
General internal medicine	0.94 (0.77–1.14)		0.90 (0.72–1.14)	
Hematology/oncology	0.34 (0.30–0.38)		1.37 (1.04–1.80)	
Gastroenterology	1.05 (0.88–1.25)		0.87 (0.72–1.05)	
Nephrology	0.98 (0.83–1.16)		0.81 (0.68–0.97)	
Infectious disease	0.84 (0.72–0.98)		0.69 (0.58–0.81)	
Pulmonology	0.47 (0.35–0.64)		0.56 (0.41–0.78)	
Neurology	1.24 (0.95–1.61)		1.16 (0.88–1.53)	
ICU	0.48 (0.42–0.54)		0.52 (0.45–0.60)	
Thorax center ICU[d]	0.54 (0.46–0.63)		0.55 (0.44–0.68)	
ER	0.26 (0.22–0.30)		0.30 (0.25–0.36)	
Other (outpatient, psychiatry, and revalidation)	0.85 (0.67–1.10)		1.48 (1.08–2.04)	
Bacterial growth		0.18		
No growth	1			
Staphylococcus aureus	1.07 (0.84–1.38)			
Coagulase-negative staphylococcus	0.83 (0.71–0.98)			
Streptococcus and *Enterococcus* spp.	0.89 (0.58–1.36)			
Enterobacteriaceae	0.86 (0.72–1.04)			
Nonfermenter	0.82 (0.55–1.23)			
Yeast	1.11 (0.69–1.78)			
2 or more different organisms	1.30 (0.89–1.90)			
Other	1.15 (0.78–1.69)			

[a] Data are shown as HR (95% CI). A variable with a HR smaller than one is associated with a longer transport time, while a variable with a HR larger than one is associated with a shorter transport time.
[b] Off-site ward data pertain to specimens transported by courier service.
[c] The difference between 4 and 8 min and off-site wards is significant.
[d] Combined departments of wards and thoracic surgery, located in a separate building but connected with the main hospital building.

creasing awareness of health care quality and effectiveness, this study addresses an important but infrequently described issue in health care execution: the transportation of specimens. The study uncovers substantial delays in transportation time that may impact culture turnaround time as well as the potential positivity rate. Thus, this study should be of considerable interest to microbiologists, clinicians, and hospital administrators.

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