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Detection of Methicillin-Resistant *Staphylococcus aureus* (MRSA) in Specimens from Various Body Sites: Performance Characteristics of the BD GeneOhm MRSA Assay, the Xpert MRSA Assay, and Broth-Enriched Culture in an Area with a Low Prevalence of MRSA Infections[▽]

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Universal surveillance upon patient admission is important in reducing the transmission of methicillin-resistant *Staphylococcus aureus* (MRSA) and associated disease in hospitals. High costs for the health care system in conjunction with MRSA have promoted the development of rapid screening methods to detect MRSA carriers. This study compared two real-time PCR methods, the BD GeneOhm MRSA assay (BDGO) and the Xpert MRSA assay, with broth-enriched culture to define their performance characteristics and rapidity in an area with low MRSA prevalence. In total, 414 swabs from the nose and 389 swabs from the groin from 425 patients were tested. Of those 425 patients, 378 had swabs from both the nose and groin in parallel. Two hundred thirty-one and 194 patients were randomly assigned to the BDGO group and the Xpert MRSA group, respectively. In general, sensitivity, specificity, and negative predictive value (NPV) were high for the BDGO (100%, 98.5%, and 100%, respectively) and the Xpert MRSA (100%, 98.2%, and 100%, respectively), irrespective of whether or not nasal and inguinal specimens were considered alone or combined. In contrast, the positive predictive value (PPV) was lower: before the resolution of discrepant results, the PPVs for nasal and inguinal specimens alone and combined were 87.5%, 86.7%, and 82.4% for the BDGO and 91.7%, 66.7%, and 92.9% for the Xpert MRSA, respectively. After the resolution of discrepant results, PPVs were 93.8%, 93.3% and 94.1% for the BDGO and 91.7%, 88.9% and 92.9% for the Xpert MRSA, respectively. With the BDGO, 4 of 16 carriers were each identified by nasal or inguinal swabs alone, whereas in the Xpert MRSA group, 4 of 13 carriers were exclusively identified by nasal swabs and 2 of 13 were identified by inguinal swabs alone. Both PCR methods showed no significant difference in the number of discrepant results (odds ratio, 0.70 [$P = 0.789$]), but specimens from wounds and other body sites (axilla, vagina, and throat) produced discrepancies more often than nasal and groin specimens (odds ratios, 4.724 [$P = 0.058$] and 12.163 [$P < 0.001$], respectively). The facts that no false-negative PCR results were detected and increased PPVs were found after the resolution of discrepant results point to PCR as the actual gold standard. Since both sensitivity and NPV were exceptionally high for PCR, backup cultures may, therefore, be unnecessary in an area with low prevalence and with a preemptive isolation strategy but may still be useful for PCR-positive specimens because of the lower PPV for both methods and the possibility of susceptibility testing. The median time for analysis, including extraction, hands-on time, and actual PCR was 2 h 20 min for the Xpert MRSA versus 5 h 40 min for the BDGO. Concerning reporting time, including administration and specimen collection, the Xpert MRSA was faster than the BDGO (7 h 50 min versus 17 h).

Methicillin-resistant *Staphylococcus aureus* (MRSA) strains have become a major concern for health care systems. Prevention of the spread of MRSA has, therefore, become a main goal in the past decade, and active screening programs have been established worldwide (4, 27). Compared to infections caused by methicillin-susceptible *S. aureus* (MSSA), the organism causes severe infections with increased morbidity and mortality and prolonged hospitalization (9, 17). Unlike countries facing a high prevalence of MRSA, such as the United States and Japan, the prevalence in Switzerland has remained low to date (5, 13, 21, 32). In most parts of our country, prevalence rates between 4% and 7% are observed (19). Apart from its spread in the hospital environment, MRSA carriage in our community, as well as in other countries, seems to be more prevalent than previously assumed (31, 32, 37).

To facilitate the rapid detection of colonized patients, real-time PCR assays have been developed. The first method to directly detect MRSA from clinical specimens was developed by Huletsky et al. (20). The principle of this method is used in two commercially available tests, the BD GeneOhm MRSA assay (BDGO) (BD, San Diego, CA) and the Xpert MRSA assay (Cepheid, Inc., Sunnyvale, CA).

Recent studies have shown that universal admission surveillance for MRSA was associated with a reduction in MRSA disease (18, 28). Likewise, Cunningham et al. have reported a reduction in MRSA transmissions in a critical care unit. The

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authors attributed these findings, at least partially, to the availability of rapid PCR screening tests, apart from other measures like improved hygiene measures (10). PCR screening methods are cost efficient, especially in an area of low prevalence where high-risk patients are subjected to preemptive contact isolation (6). Our facility is a 1,000-bed tertiary care teaching hospital with a known low prevalence (<5%) of MRSA colonization of patients and follows a surveillance policy similar to that of the University Hospital of Berne, Switzerland (6). As reported in other studies, this means preemptive isolation on admission of all patients who (i) came from or had traveled to countries with known high prevalence rates for MRSA, (ii) were transferred from long-term care facilities, (iii) were transferred from another health care facility, (iv) were hospitalized within the previous 6 months, and/or (v) had a history of MRSA colonization or infection (6, 8, 23). As soon as PCR is negative for MRSA, patient isolation is ended. Under these circumstances, a rapid screening method with a high negative predictive value (NPV) is desirable, because the bulk of costs emerge mainly from noncolonized patients being unnecessarily isolated. In this study, we compared two real-time PCR methods, the BDGO and Xpert MRSA assays, with broth-enriched culture to assess their performance characteristics and rapidity in an area with a low prevalence of MRSA.

MATERIALS AND METHODS

Patients and clinical specimens. This study was conducted prospectively over a period of 12 months, from August 2007 to August 2008, at the Luzerner Kantonsspital (LUKS). Swabs from the nose, groin, wounds, axilla, vagina, and throat were collected on admission according to the LUKS policy for MRSA screening for patients with a high risk for MRSA carriage. High-risk patients were individuals who (i) came from or had traveled to countries with known high rates of prevalence of MRSA, (ii) were transferred from long-term care facilities, (iii) were transferred from another health care facility, (iv) were hospitalized within the previous 6 months, and/or (v) had a history of MRSA colonization or infection. Double swabs were transported in Copan Transystem liquid Stuart (Copan Italia S.p.A., Brescia, Italy) and stored at room temperature. If further processing of the swabs was not possible on the same day, swabs were stored overnight at 4°C. Patient samples were then randomly assigned to be tested with either the BDGO or the Xpert MRSA assay.

BD GeneOhm MRSA assay. Swabs were transferred to the sample reagent buffer and processed for cell lysis and DNA extraction according to the manufacturer's recommendations. The lysed specimen (2.8 μl) was added to the PCR tubes containing 25 μl of the reconstituted master mix. PCR was performed with a SmartCycler II instrument (Cepheid, Sunnyvale, CA). Positive and negative controls were included in each run. In case of inhibition, the sample was briefly frozen to remove inhibitors and the run repeated. If a sample was still inhibited after freezing-thawing, the lysed specimen was diluted 1:20 with sample reagent buffer and the run repeated. The BDGO is both Food and Drug Administration (FDA) approved in the United States and CE approved in Europe for nasal specimens exclusively. Since the manufacturer provides instructions for nasal swabs only, specimens from body sites other than the nares were treated the same as the nasal ones.

Xpert MRSA assay. Swabs were transferred into extraction buffer vials and mixed to remove bacteria from the swab according to the manufacturer's instructions. Again, only nasal specimens are FDA and CE approved. Specimens from body sites other than the nares were treated the same as nasal specimens.

Detection of MRSA by culture. In parallel to PCR, the second part of the double swab was transferred into enrichment broth (1 ml; tryptic soy broth [Becton Dickinson, Franklin Lakes, NJ] supplemented with 7.5% NaCl) and incubated for 24 h in ambient air at 35°C. Subcultures were done on chromogenic agar medium (ChromID MRSA agar; bioMérieux, Marcy l'Etoile/France) at 35°C in ambient air. Plates were read after 24 and 48 h of incubation, respectively. Blue colonies were tested using the Staphaurex Plus test (Remel Europe Ltd., Dartford, Kent, United Kingdom). The presence of MRSA was confirmed with the Vitek 2 system (GP colorimetric identification card and software version 04.03; bioMérieux). Susceptibility testing for confirmation of methicillin resistance was done by the disk diffusion method with 30-μg-cefoxitin disks (bioMérieux) according to the guidelines of the Clinical and Laboratory Standards Institute (CLSI) (7).

Calculation of inhibition rates. The initial inhibition rates were recorded for both test systems. For the BDGO, inhibition rates were recalculated after freezing-thawing and after freezing-thawing and diluting the sample 1:20 with sample reagent buffer. For the Xpert MRSA assay, repeating a test was not possible.

Resolution of discrepant results. Specimens showing discrepant results for the BDGO and Xpert MRSA assays and culture were further analyzed. In case of PCR-positive but culture-negative results from one body site and concordantly positive results of specimens from another body site of the same patient at the same time, PCR results were regarded as true positives (TP).

Data analysis of PCR results. Specificity, positive predictive value (PPV), and NPV were calculated for the BDGO and the Xpert MRSA assay compared to culture as the gold standard before and after the resolution of discrepant results. Confidence intervals were calculated according to Wilson's method (1, 25), and odds ratios were calculated for the frequency of results that were discrepant with those of culture, comparing results for both PCR-based methods in general and for different types of specimens with nasal specimens as the FDA-approved reference by logistic regression adjusted for clustering.

Calculation of turnaround times. The transport time (from collection to arrival at the laboratory) and laboratory turnaround time (from arrival of the specimen to reporting of either PCR or culture results) were recorded electronically in hours and minutes for each specimen, and the median times were calculated. The reporting time (sampling to reporting of results) was calculated as the sum of transport and laboratory turnover times.

Software. All calculations were done with Microsoft Excel Software (Microsoft, Redmond, WA) and Stata software (StataCorp LP, College Station, TX). Results with P values of <5% were considered statistically significant.

RESULTS

In total, 414 swabs from the nose and 389 swabs from the groin from 425 patients were tested. Of those 425 patients, 378 had swabs from both nose and groin in parallel. Two hundred thirty-one and 194 patients were randomly assigned to the BDGO group and the Xpert MRSA group, respectively.

In the BDGO group, 8 of 13 initially inhibited specimens could eventually be included in the data analysis because results became available after a freezing/thawing step. The remaining 5 specimens could be included after a freezing/thawing step plus a 1:20 dilution step of the extracted DNA. Specimens from 7 of 194 patients in the Xpert MRSA group were excluded from the study due to persistent PCR inhibition.

The initial inhibition rates with swabs from the nose and groin were comparably low in the BDGO group (1.7% and 1.3%, respectively) and the Xpert MRSA group (1.6% and 1.7%, respectively). For wound specimens, the Xpert MRSA showed distinctly lower initial inhibition rates than the BDGO (0% and 6.2%, respectively). Repeat PCRs were possible with the BDGO samples, and the inhibition rate dropped to zero after a freezing/thawing step followed by a 1:20 dilution of the lysate.

Performance characteristics of the BDGO and Xpert MRSA were calculated for each specimen type separately and for nose and groin specimens combined, before and after resolution of discrepant results, using broth-enriched culture as the gold standard (Tables 1 and 2). No significant differences in the performance of the two PCR methods were observed. The sensitivity, specificity, and negative predictive value (NPV) of the BDGO were already high before the resolution of discrepant results (100%, 98.5%, and 100%, respectively), irrespective of whether results for body sites were considered alone or combined. The same was true for the Xpert MRSA, with a sensitivity, specificity, and NPV of 100%, 98.2% and 100%,

TABLE 1. Performance parameters of the BD GeneOhm (BDGO) and Xpert MRSA assays and culture[a]

Time of assessment, origin of specimen, method	No. of samples	No. of samples with indicated result				Sensitivity		Specificity		PPV		NPV	
		TP	FP	TN	FN	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Before resolution of discrepant results													
Nose													
BDGO	228	14	2	212	0	100	78.5–100	99.1	96.7–99.7	87.5	64.0–96.5	100	98.2–100
Xpert MRSA	186	11	1	174	0	100	74.1–100	99.4	96.8–99.9	91.7	64.6–98.5	100	97.8–100
Groin													
BDGO	213	13	2	198	0	100	77.2–100	99.0	96.4–99.7	86.7	62.1–96.3	100	98.1–100
Xpert MRSA	176	6	3	167	0	100	61.0–100	98.2	94.9–99.4	66.7	35.4–87.9	100	97.8–100
Nose and groin combined													
BDGO	210	14	3	193	0	100	78.5–100	98.5	95.6–99.5	82.4	59.0–93.8	100	98.0–100
Xpert MRSA	168	13	1	154	0	100	77.2–100	99.4	96.4–99.9	92.9	68.5–98.7	100	97.6–100
After resolution of discrepant results													
Nose													
BDGO	228	15	1	212	0	100	79.6–100	99.5	97.4–99.9	93.8	71.7–98.9	100	98.2–100
Xpert MRSA	186	11	1	174	0	100	74.1–100	99.4	96.8–99.9	91.7	64.6–98.5	100	97.8–100
Groin													
BDGO	213	14	1	198	0	100	78.5–100	99.5	97.2–99.9	93.3	70.2–98.8	100	98.1–100
Xpert MRSA	176	8	1	167	0	100	67.6–100	99.4	96.7–99.9	88.9	56.5–98.0	100	97.8–100
Nose and groin combined													
BDGO	210	16	1	193	0	100	80.6–100	99.5	97.1–99.9	94.1	73.0–99.0	100	98.0–100
Xpert MRSA	168	13	1	154	0	100	77.2–100	99.4	96.4–99.9	92.9	68.5–98.7	100	97.6–100

[a] Values and corresponding 95% confidence intervals (CI) for specimens from nose and groin alone and combined were calculated before and after resolution of discrepancies. TP, true positive; TN, true negative; FP, false positive; FN, false negative; PPV, positive predictive value; NPV, negative predictive value.

respectively. After resolution of discrepancies, the sensitivities, specificities, and negative predictive values changed marginally, to 100%, 99.5%, and 100% for the BDGO and 100%, 99.4%, and 100% for the Xpert MRSA, respectively. In contrast, the positive predictive values (PPV) were lower: before the resolution of discrepant results, the PPVs for nasal specimens were 87.5% and 91.7% for the BDGO and Xpert MRSA, respectively. After the resolution of discrepant results, the PPV for nasal specimens rose to 93.8% for the BDGO and remained 91.7% for the Xpert MRSA. For specimens from the groin, the PPVs were only 86.7% and 66.7% before the resolution of discrepant results and rose to 93.3% and 88.9% after the resolution of discrepant results for the BDGO and Xpert MRSA, respectively. Combining specimens from nose and groin resulted in PPVs of 82.4% and 92.9% before the resolution of discrepancies and 94.1% and 92.9% after the resolution of discrepancies for the BDGO and Xpert MRSA, respectively.

Taking swabs from the nose and groin resulted in a higher rate of detection of MRSA carriers. In the BDGO group with specimens from nose and groin, 4 of 16 carriers were each identified by nasal or inguinal swabs alone, whereas 8 carriers showed positive PCR results with both body sites. In the Xpert MRSA group with specimens from nose and groin, 4 of 13

TABLE 2. Analysis of discrepant results of PCR-based methods and culture

PCR method	Patient	Origin of specimen	Result of further analyses	Organism cultured[a]	Rating of PCR result[b]	
					Before resolution of discrepancy	After resolution of discrepancy
BDGO	1	Nose	MRSA not detected in other specimens from the same patient	CoNS	FP	FP
		Inguina		MSSA	FP	FP
	2	Inguina	MRSA confirmed in other specimens from the same patient	None	FP	TP
	3	Nose	MRSA confirmed in other specimens from the same patient	CoNS	FP	TP
Xpert MRSA	4	Nose	MRSA not detected in other specimens from the same patient	*S. sciuri*	FP	FP
		Inguina			FP	FP
	5	Inguina	MRSA confirmed in other specimens from the same patient	CoNS	FP	TP

[a] MSSA, Methicillin-susceptible *Staphylococcus aureus*; CoNS, coagulase-negative staphylococci.
[b] TP, true positive; TN, true negative; FP, false positive; FN, false negative.

TABLE 3. Median times for sample processing[a]

Method	Time (h:min) required for:			Time to reporting
	Transport	Collection	Analysis	
BDGO	4:25	6:55	5:40	17:00
Xpert MRSA	4:25	1:05	2:20	7:50
Culture	4:25	Directly inoculated	54:30	68:50

[a] Transport time (from collection to arrival at the laboratory) and laboratory turnaround time (from arrival to reporting of either PCR or culture results) were calculated, the latter being divided into time for specimen collection and time for running the assay. Collection includes administration and accumulation of specimens to utilize the master mix to full capacity (BDGO only). Analysis includes DNA extraction and PCR. Time to reporting (from sampling to reporting of results) was calculated as the sum of transport and laboratory turnaround times.

carriers were exclusively identified by nasal swabs and 2 of 13 were identified by inguinal swabs alone, whereas 7 carriers showed positive PCR results with both body sites.

Additionally, the probability of producing discrepant results was analyzed by logistic regression adjusted for clustering to compare both PCR methods, as well as different body sites. If both PCR tests were compared independent of the body site, there was no difference in the probability of producing results discrepant with those of culture (odds ratio, 0.70 [$P = 0.789$]). To compare the results for body sites, nasal specimens were chosen as the comparator as they are widely accepted and approved by the FDA. In addition to specimens from the groin ($n = 389$), other body sites were included in the analysis (wounds [$n = 99$], axilla [$n = 24$], throat [$n = 11$], and vagina [$n = 3$]). If body sites were compared in regard to the probability of discrepant results (in our case for PCR-positive, culture-negative results [FP] only), significant differences were detected independent of the PCR method: specimens from the groin tended to produce discrepant results more often than nasal specimens (odds ratio, 1.09 [$P = 0.001$]), while specimens from wounds and various other body sites (axilla, vagina, and throat) exhibited a distinctly higher probability of discrepant results (odds ratios, 4.724 [$P = 0.058$] and 12.163 [$P < 0.001$], respectively).

The turnaround times for the BDGO and Xpert MRSA are shown in Table 3. The transport time was the same for both assays, but the reporting times of the PCR methods differed: the Xpert MRSA had a reporting time of 7 h 50 min and, thus, provided results to the clinicians 9 h and 10 min earlier than the BDGO.

DISCUSSION

Several recent studies have compared the BDGO and Xpert MRSA assays in countries with a high prevalence of MRSA (22, 29, 34–36). In our study, we not only compared classical performance parameters like sensitivity, specificity, PPV, and NPV in an area with a low prevalence but also analyzed the likelihood of discrepant PCR and culture results for specimens from body sites other than the nares. In addition, we assessed the rapidity with which the respective results became available.

Both PCR assays had comparable sensitivities, specificities, PPVs, and NPVs, similar to what has been observed by others (2, 11, 22, 26, 33, 35). Notably, the sensitivity of the BDGO in this study was found to be higher (100% versus 84.3%) than in our previous study (23). This may possibly be attributed to the use of Amies gel agar in the previous study instead of liquid Stuart's medium as used in the current one. The use of an agar-based medium may compromise the elution process for staphylococcal organisms.

Most recently, Kelley et al. (22) reported that sampling more than a single body site with pooled swabs from nose and groin resulted in a higher colonization detection rate for PCR screening assays in an area with high MRSA prevalence (2, 14, 22, 24), while sensitivities and PPVs (ranging from 84.8% to 87% and from 76.5% to 80%, respectively) were relatively low. Our results support those findings, inasmuch as the rates of detection of MRSA carriers were increased by 25% (4 of 16 carriers) and 15.4% (2 of 13 carriers) with the BDGO and Xpert MRSA, respectively, if swabs from the groin were added to those from the nares. The sensitivity, specificity, PPV, and NPV of combined swabs equaled the performance values of swabs from a single body site. Thus, two advantages of pooling specimens from the nose and groin are a lower cost for MRSA screenings along with an enhanced detection rate of MRSA carriers. However, for specific decolonization procedures, additional testing will be necessary to determine the sites actually colonized, offsetting the cost savings from pooling samples.

As pointed out by Conterno et al., screening patients by PCR was more costly than screening them with cultural methods despite an extended period of isolation associated with culture (8). However, 37% of the cost could be attributed to the high rate (41.4%) of patients isolated because of false-positive results that resulted from a low PPV (65%) of the IDI-MRSA assay used (now BDGO). On the one hand, PCR-positive, culture-negative results may be attributed to high colonization rates, e.g., in wounds infected with MSSA containing staphylococcal cassette chromosome *mec* (SCC*mec*)-like elements without a functional *mecA* gene which are inserted in the same integration site as SCC*mec* and reportedly may result in true false-positive PCR results (12, 15) or, on the other hand, lower colonization rates, below the detection limit of culture, of other body sites (29, 30). For a single discrepant result with the Xpert MRSA (Table 2, patient 4), we found no possible explanation: MRSA could not be detected in other specimens from the same patient (pointing to an actual true-positive PCR result), nor could MSSA be cultured from this specimen (pointing to a true false-positive PCR result). Interestingly, *Staphylococcus sciuri* was isolated from culture and identified by biochemical and 16S rRNA gene homology analysis. Hence, the PCR result was considered false positive after the resolution of discrepancies. The reason for the positive PCR result remains unclear. Work is in progress to further characterize this strain. However, *S. sciuri* is a rarely isolated species in humans and may bias our results, as this specimen was the only false positive after the resolution of discrepancies with the Xpert MRSA. Thus, the actual PPV of the Xpert MRSA in routine use may even be higher than reported in this study. The results of Wolk et al. (35) for nasal specimens parallel those of our study using various specimen types. Their study and our own results (no false-negative PCRs and a sensitivity of 100%) suggest that the low PPV of PCR assays may result from the higher sensitivity of PCR assays than of culture, i.e., PCR is the likely new gold standard. Our results support those findings inasmuch as 3 of 7 specimens with PCR-positive,

culture-negative results were obtained along with positive parallel specimens from the same patient at the same time, pointing to true-positive PCRs and false-negative cultures which resulted in an increased PPV (Tables 1 and 2). Furthermore, our data show that discrepant results for both PCR methods—exclusively FP—occurred significantly more frequently with swabs from body sites other than the nares and groin and, therefore, contribute to a low PPV. This may be due to lower MRSA colonization rates and, therefore, lower pretest probability for sites like the throat, axilla, or vagina than for the nares (3, 24). Although the recommendation has been made to include at least throat specimens for optimal sensitivity, our results indicate that a sensitivity of 100% can be achieved with nasal and inguinal swabs alone (24). Thus, testing of body sites other than the nares and groin may be dispensable.

Another disadvantage of swabs from body sites other than the nares and groin may be the higher inhibition rates (1 of 17 swabs and 2 of 22 swabs from other body sites compared to only 7 of 414 and 6 of 389 for nose and groin swabs for BDGO and Xpert MRSA, respectively). With specimens from wounds, 4 of 65 invalid results were observed with the BDGO, while with the Xpert MRSA, none were seen (0 of 34). The numbers of invalid final results due to inhibition were comparably low for nose and groin specimens in both PCR assays (1.3% to 1.7% and 1.5% to 1.6% for the BDGO and Xpert MRSA, respectively). For the nose and groin swabs analyzed by the BDGO, this is well in line with previous reports (2, 11, 23, 33). The initial inhibition rates of the BDGO can be reduced by applying a freezing/thawing step to the DNA extract (12, 22, 38) or even be completely overcome by an additional dilution step (23, 38). If, however, persistent PCR inhibition is observed for a specimen, it seems reasonable to do cultures and keep the patient isolated until results become available. In the case of the Xpert MRSA, our inhibition/invalid-result rates are far below the values generally observed, ranging from 4% (29) for nasal swabs up to 20.9% (22) for nose and groin swabs combined. These high rates may be due to the formation of crystals in the cartridges (22). Therefore, prewarming of the reagents prior to repeating the test has been suggested, a strategy which, however, will increase cost (22). Since we stored the reagents at 4°C and did not prewarm them prior to use, the reason for our lower inhibition rates remains unknown.

In addition to the classical performance characteristics, a short reporting time for MRSA detection is crucial to reduce both the rate of nosocomial MRSA transmission and the number of patient isolation days (4, 16, 27). Primarily, reporting time depends on turnaround time in the laboratory, including (i) collection time to accumulate enough specimens in the laboratory to use the PCR master mix to its full capacity (for the BDGO only), (ii) preanalytic steps, and (iii) the time needed to perform the assay. The BDGO is available for batched, single-use master mix vials for as many as 6 specimens plus 2 controls. In this case, collection time in the laboratory is an important parameter. If used in a hospital with a low prevalence of MRSA carriers, there will be a limited number of screening tests. For financial reasons, laboratories will try to accumulate specimens for up to 6 tests before performing the assay. As a consequence, results may be delayed. Conversely, the Xpert MRSA cartridges may be used for a single specimen at any time and, therefore, such limitations do not apply for this method.

In contrast to the fully automated GeneXpert system, another drawback of the BDGO affecting rapid availability of results is the higher complexity of the system due to the manual DNA extraction procedure. This will considerably increase the overall time for analysis (in our study, 2 h 20 min for the Xpert MRSA versus 5 h 40 min for the BDGO, respectively). Our data, however, represent the situation in an area of low prevalence with low numbers of MRSA screening tests per day. As a consequence, this considerably increased the reporting time for the BDGO. The reporting time may decrease in areas of high prevalence where screening tests are performed more frequently, i.e., full BDGO batches are achieved more rapidly.

Altogether, the reporting time for results with the Xpert MRSA in our setting was 9 h shorter than for results generated by the BDGO. Since the performance characteristics of both PCR assays were quite comparable, the Xpert MRSA may outperform the BDGO because of rapidity and associated cost savings for the hospital, at least if a preemptive isolation strategy is applied. In contrast, if considered per specimen, the Xpert MRSA disposables are more expensive than the BDGO master mix used to its full capacity. This holds true, in particular, for areas with a high prevalence of MRSA where large numbers of screening tests are performed and, as a consequence, the BDGO master mix will be used up regularly, resulting in lower laboratory costs.

Six major conclusions can be drawn from our study. (i) Both PCR methods performed equally well regarding sensitivity, specificity, PPV, and NPV, as well as the probability of producing results discrepant from the results of culture. (ii) Combining swabs from nose and groin increases the rate of detection of MRSA carriers. (iii) Taking swabs from body sites other than the nares and groin may not be advisable because of higher inhibition rates and a significantly increased likelihood of discrepant results. (iv) The NPV was exceptionally high (100%) for both PCR methods, demonstrating that back-up cultures are unnecessary if PCR is negative. For PCR-positive specimens, back-up cultures may, however, be useful because of the low PPV even after the resolution of discrepancies. (v) The low PPV of both PCR methods might be due to PCR rather than culture being the actual gold standard. Culture, in all likelihood, produces false-negative results and, therefore, is not a true gold standard. (vi) Concerning rapid availability of PCR results, the Xpert MRSA was superior to the BDGO.

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