Published in final edited form as:

Eur J Clin Microbiol Infect Dis. 2011 November ; 30(11): 1425–1430. doi:10.1007/s10096-011-1237-7.

Comparison of culture media for detection of *Acinetobacter baumannii* in surveillance cultures of critically-ill patients

A. O. Ajao,

Department of Epidemiology and Public Health, University of Maryland School of Medicine, 685 W. Baltimore St, Baltimore, MD 21201, USA

G. Robinson,

Department of Epidemiology and Public Health, University of Maryland School of Medicine, 685 W. Baltimore St, Baltimore, MD 21201, USA

M. S. Lee,

Department of Epidemiology and Public Health, University of Maryland School of Medicine, 685 W. Baltimore St, Baltimore, MD 21201, USA

T. D. Ranke,

Department of Epidemiology and Public Health, University of Maryland School of Medicine, 685 W. Baltimore St, Baltimore, MD 21201, USA

R. A. Venezia,

Department of Pathology, University of Maryland School of Medicine, 685 W. Baltimore St, Baltimore, MD 21201, USA

J. P. Furuno,

Department of Epidemiology and Public Health, University of Maryland School of Medicine, 685 W. Baltimore St, Baltimore, MD 21201, USA

A. D. Harris, and

Department of Epidemiology and Public Health, University of Maryland School of Medicine, 685 W. Baltimore St, Baltimore, MD 21201, USA

J. K. Johnson

Department of Epidemiology and Public Health, University of Maryland School of Medicine, 685 W. Baltimore St, Baltimore, MD 21201, USA

Department of Pathology, University of Maryland School of Medicine, 685 W. Baltimore St, Baltimore, MD 21201, USA

A. O. Ajao: aajao@epi.umaryland.edu

Abstract

The objective of this study was to evaluate the performance of CHROMagar *Acinetobacter* when compared to sheep blood agar, MacConkey agar and MacConkey agar with 6 µg/ml of imipenem for the detection of *A. baumannii* in surveillance cultures of hospitalized patients. We utilized peri-anal swabs and sputum samples from patients admitted to the University of Maryland Medical Center ICUs from December 7 through December 21, 2009. Samples were plated onto four media in the following order: (1) 5% sheep blood agar (SBA), (2) MacConkey agar, (3)

MacConkey agar with 6 µg/ml of imipenem, and (4) CHROMagar *Acinetobacter* (CHROMagar). SBA was the gold standard to which all media was compared. There were 165 samples collected during the study period. SBA and CHROMagar detected 18 of 18 (100%) *Acinetobacter* and 11 of 11 (100%) MDR-*A. baumannii*. MacConkey agar detected 16 of 18 (89%) *Acinetobacter* and 10 of 11 (91%) MDR-*A. baumannii* while MacConkey agar with 6 µg/ml imipenem detected 9 of 11 (82%) MDR-*A. baumannii*. CHROMagar did not differentiate MDR-*A. baumannii* from non-MDR-*A. baumannii*. CHROMagar may be useful for rapid detection of patients with MDR-*A. baumannii* if improved upon to better select for MDR-*A. baumannii*.

Introduction

Acinetobacter species, especially *A. baumannii*, has emerged as an important nosocomial pathogen contributing to increased morbidity and mortality among infected patients [1–3]. *A. baumannii* causes a wide range of infections including hospital-acquired pneumonia, respiratory-tract infection, urinary tract infections, surgical site infections, and bloodstream infections [4]. Furthermore, *A. baumannii* is resistant to multiple classes of commonly-used antibiotics, thus complicating treatment of these infections [5]. Multiple outbreaks due to *A. baumannii* have been reported globally [6–11]. These outbreaks have primarily been in intensive care units (ICUs) [7,11]; however, outbreaks have also occurred in surgical wards, burn units and general medical wards [6, 8–10]. Increased morbidity and mortality associated with the outbreaks have prompted some hospitals to begin performing active surveillance in high-risk patients in an attempt to control the spread of *A. baumannii* [12]. Currently, there is no recommended medium for screening of surveillance and clinical cultures for *A. baumannii*. Sheep blood agar and MacConkey agar are conventionally used for detection of *A. baumannii* in clinical cultures; however, these methods are non-selective for *A. baumannii*. Thus detection and isolation of *A. baumannii* from surveillance and clinical cultures is laborious and requires several days due to the presence of other bacteria species present in the human flora [13]. In contrast, chromogenic media that can rapidly identify patients colonized or infected with *A. baumannii* may improve the efficiency of infection control practices, shorten the time to delivery of appropriate antibiotic therapy for infected patients and reduce mortality [14]. The University of Maryland Medical Center (UMMC) utilizes an in-house selective media consisting of MacConkey agar supplemented with 6 µg/ml of imipenem to select for multidrug resistant (MDR)-*A. baumannii* in surveillance cultures.

Chromogenic media are culture media that are designed for rapid and simple detection of bacteria. They contain chromogenic substrates that are cleaved by enzymes produced by bacteria resulting in unique coloration of the colonies of each bacteria strain allowing for easy identification. Currently, there are numerous chromogenic media that are commercially available and commonly used for rapid detection of colonization with organisms that cause hospital acquired infections such as methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant enterococci, extended-spectrum beta-lactam-producing bacteria and carbapenem-resistant bacteria [15–21].

CHROMagar *Acinetobacter* is a recently developed chromogenic media designed for detection and isolation of *Acinetobacter* species. This media inhibits the growth of most gram-positive cocci and yeast and employs a color-change identification method that allows *Acinetobacter* species to appear as red colonies. The objective of this study was to evaluate the performance of CHROMagar *Acinetobacter* when compared to sheep blood agar, MacConkey agar and MacConkey agar with 6 µg/ml of imipenem for detection and isolation of *A. baumannii* in infection control surveillance cultures of hospitalized patients.

Materials and methods

Sample collection

We utilized leftover peri-anal swabs and sputum samples obtained from a cohort of patients admitted to UMMC medical intensive care unit (MICU) and surgical intensive care unit (SICU) for surveillance of vancomycin-resistant enterococci from December 7, 2009 through December 21, 2009. Peri-anal swabs were obtained routinely from all patients upon ICU admission. Sputum samples were collected in sputum traps from patients who were ventilated during their ICU admission. These samples were collected as part of routine infection control surveillance; therefore, individual informed consent was not sought prior to including their samples in the study. This study was approved by the Institutional Review Board of the University of Maryland, Baltimore.

Media preparation

This study used a formulation of CHROMagar *Acinetobacter* that was designed for the detection of *Acinetobacter* species. CHROMagar *Acinetobacter* was prepared from dehydrated powder and liquid supplement according to manufacturer's instructions (Chromagar; Paris, France). MacConkey agar with imipenem was prepared in house from dehydrated MacConkey powder according to manufacturer's instructions (BD, Sparks, MD), and supplemented with 300 µl of 20 mg/ml stock of imipenem solution per one liter of MacConkey solution for a final concentration of 6 µg/ml. An imipenem concentration of 6 µg/ml was chosen to select for intermediate and resistant *A. baumannii* using Clinical and Laboratory Standard Institute (CLSI) breakpoints [22–24]. MacConkey agar and sheep blood agar plates were purchased directly from the manufacturer (BD, Sparks, MD).

Agar inoculation and comparison

Peri-anal swabs and sputum samples were inoculated directly onto the four agar media in this order: (1) 5% sheep blood agar, (2) MacConkey agar, (3) MacConkey agar with 6 µg/ml of imipenem, and (4) CHROMagar *Acinetobacter*. The same swab was inoculated onto each media and rotated completely. Plates were streaked for isolation and incubated at 37°C for 24 hours. The same laboratory technician evaluated all four plates for a specific patient sample. CHROMagar *Acinetobacter* and MacConkey agar were compared to sheep blood agar for detection of *Acinetobacter* species, while CHROMagar *Acinetobacter*, MacConkey agar, and MacConkey agar with 6 µg/ml of imipenem were compared to sheep blood agar for isolation of MDR-*Acinetobacter*. Thus, for all comparisons in this study, sheep blood agar was considered the gold standard.

Colony identification and susceptibility testing

Oxidase negative colonies morphologically similar to *Acinetobacter* were identified using the Vitek II (bioMérieux; Durham, NC). Susceptibilities were performed by disk diffusion method and E-tests (bioMérieux; Durham, NC) and interpreted based on current CLSI guidelines [22]. *Acinetobacter* isolates were tested against imipenem, doripenem, meropenem, ertapenem, sulfamethoxazole-trimethoprim, ampicillin-sulbactam, piperacillin-tazobactam, ceftazidime, cefepime, ciprofloxacin, amikacin, gentamicin, polymyxin B, and tigecycline. Multidrug resistance was defined as susceptible to two or fewer antibiotics not including polymyxin B and tigecycline [24].

Results

There were 165 surveillance samples (153 peri-anal swabs and 12 sputum samples) received at the UMMC microbiology laboratory from 165 unique patients admitted to the MICU and SICU during the 2-week study period. Only 12 sputum samples were collected due to the

small number of patients ventilated during their ICU stay. Of the 165 samples collected, 17 samples (10.3%) which consisted of 12 peri-anal swabs and five sputum samples yielded *Acinetobacter* from sheep blood agar. One peri-anal swab yielded two morphologically different *A. baumannii* isolates resulting in a total of 18 *Acinetobacter* species isolated and identified. Of the 18 *Acinetobacter* isolates, 17 were identified as *A. baumannii* and one was identified as *A. Iwoffii*. The two morphologically different *A. baumannii* isolates recovered from the same peri-anal swab had different antibiotic susceptibility profiles. One of the two isolates was identified as an MDR-*A. baumannii* while the other isolate was identified as a non-MDR-*A. baumannii*. The non-MDR-*A. baumannii* isolate was recovered from all four media while the MDR-*A. baumannii* isolate was recovered from sheep blood agar, MacConkey agar with 6 µg/ml of imipenem and CHROMagar *Acinetobacter* but not from MacConkey agar. On CHROMagar *Acinetobacter*, both isolates appeared as red colonies but the MDR-*A. baumannii* isolate appeared as round and smooth colonies while the non-MDR-*A. baumannii* isolate appeared as mucoid and spready colonies.

Sheep blood agar and CHROMagar *Acinetobacter* recovered 18 of 18 (100%) *Acinetobacter* isolates while MacConkey agar recovered 16 of 18 (89%) *Acinetobacter* isolates. The isolate identified as *Acinetobacter Iwoffii* was a non-MDR-*Acinetobacter* and was recovered by sheep blood agar, CHROMagar *Acinetobacter* and MacConkey agar. Of the 18 *Acinetobacter* identified, 11 (61%) were identified as MDR-*A. baumannii*. The 11 MDR-*A. baumannii* were detected and isolated from eight peri-anal swabs and three sputum samples. Sheep blood agar and CHROMagar *Acinetobacter* recovered 11 of 11 (100%) MDR-*A. baumannii*. MacConkey agar recovered 10 of 11 (91%) MDR-*A. baumannii*. MacConkey agar with 6 µg/ml imipenem recovered 9 of 11 (82%) MDR-*A. baumannii*. The two MDR-*A. baumannii* that did not grow on MacConkey agar with 6 µg/ml imipenem had imipenem minimum inhibitory concentration (MIC) of 6 µg/ml. All MDR-*A. baumannii* identified were resistant to imipenem, doripenem, meropenem, ertapenem, piperacillin tazobactam and ciprofloxacin. Ten of the 11 MDR-*A. baumannii* (91%) were resistant to ceftazidime, 9 (82%) were resistant to ampicillin-sulbactam, 8 (73%) were resistant to amikacin, 7 (64%) were resistant to cefepime, and 5 of the 11 MDR-*A. baumannii* (46%) were resistant to gentamicin (Table 1).

On CHROMagar *Acinetobacter*, all *Acinetobacter* species appeared as bright salmon-red colonies at 24 hours. Colony morphology of MDR and non-MDR-*Acinetobacter* was indistinguishable on CHROMagar *Acinetobacter*. CHROMagar *Acinetobacter* also allowed growth of other red colonies. These red colonies were identified as other gram-negative bacteria other than *Acinetobacter* and were distinguishable from *Acinetobacter* colonies by variation of their red color, colony morphology and oxidase reaction. Six isolates appeared as shiny red colonies, tested oxidase-positive and were identified as *Pseudomonas* species. Three isolates appeared as pinpoint red-orange colonies with clear peripheral edges, tested oxidase-negative and were identified as *Stenotrophomonas maltophilia*. Two isolates appeared as pinpoint dark red colonies, tested oxidase-positive and were identified as *Achromobacter xylosoxidans* (Fig. 1).

Discussion

The objective of this study was to evaluate the performance of CHROMagar *Acinetobacter* when compared to sheep blood agar, MacConkey agar and MacConkey agar with 6 µg/ml of imipenem for detection and isolation of *A. baumannii* in infection control surveillance cultures of hospitalized patients. Sheep blood agar, an enriched media that allows for the growth of most bacterial species, was the gold standard to which all other media were compared in this study.

Our study results suggest that CHROMagar *Acinetobacter* was 100% sensitive for both MDR and non-MDR-*Acinetobacter* when compared to sheep blood agar. *Acinetobacter* species appeared as bright salmon red colonies on CHROMagar *Acinetobacter* facilitating easier identification and isolation. However, CHROMagar *Acinetobacter* did not differentiate MDR from non-MDR-*Acinetobacter* and further susceptibility testing is needed to confirm multidrug resistance status. In addition, CHROMagar *Acinetobacter* allows growth of red colonies that were identified as other gram-negative bacteria besides *Acinetobacter*; however, these other bacteria could be distinguished from *Acinetobacter* by variation of their red color, colony morphology and oxidase reaction.

MacConkey agar was 89% sensitive for *Acinetobacter* species and 91% sensitive for MDR-*A. baumannii* when compared to sheep blood agar. It is unlikely that depletion of bacteria colonies on the inoculation swab is responsible for the *Acinetobacter* isolates that were not recovered by MacConkey agar since CHROMagar *Acinetobacter* was inoculated last and recovered all *Acinetobacter* isolates. MacConkey agar may be reliable for isolating *Acinetobacter* species but it is non-selective for *Acinetobacter* and does not differentiate *Acinetobacter* from other non-lactose fermenting gram-negative bacteria. Thus differentiating and isolating *Acinetobacter* from other non-lactose fermenting gram-negative bacteria on MacConkey agar may still be laborious and time-consuming.

MacConkey agar with 6 µg/ml imipenem was 82% sensitive for MDR-*A. baumannii* when compared to sheep blood agar. The two MDR-*A. baumannii* that were not recovered by MacConkey agar with 6 µg/ml imipenem had imipenem MICs of 6 µg/ml. It is possible that MDR-*Acinetobacter* with MIC for imipenem that is close to the breakpoint for intermediate resistance may be missed with 6 µg/ml of imipenem.

Other selective media have been previously developed and compared for the detection and isolation of *Acinetobacter* species. Jawad et al. compared Herellea agar, Holten agar and Leeds *Acinetobacter* media (LAM) and reported that both Herellea agar and Holten agar have low sensitivity for *Acinetobacter* when compared to LAM. The study result suggested that LAM was better at selecting for and differentiating *Acinetobacter* from other bacteria present in the clinical and environmental samples tested. However, LAM was not commercially available in the United States during our study period and was not included in our comparative study [25].

Previous studies have compared CHROMagar *Acinetobacter* to other methods for detecting *Acinetobacter*. Gordon et al. compared CHROMagar *Acinetobacter* to a molecular method for the ability to detect MDR-*A. baumannii* in enteric samples of critically ill patients. The CHROMagar evaluated in the study by Gordon et al. was an investigational culture media different from the one evaluated in our study. Their CHROMagar *Acinetobacter* contained agent that inhibits the growth of most gram-positive bacteria as well as carbapenem-susceptible gram-negative bacteria while allowing *Acinetobacter* to appear as aqua blue colonies instead of the red colonies in our study. Their study reported that CHROMagar *Acinetobacter* was both sensitive (91.7%) and specific (89.7%) for MDR-*A. baumannii* when compared to PCR [26].

Another study by Akers et al. evaluated CHROMagar *Acinetobacter* for the ability to distinguish carbapenem-resistant and carbapenem-susceptible-*A. baumannii*. Their study reported that CHROMagar *Acinetobacter* was unable to distinguish carbapenem-resistant from carbapenem-susceptible-*A. baumannii*. In addition, various other organisms such as *P. aeruginosa*, *E. cloacae* and *S. aureus* grew on CHROMagar *Acinetobacter* with the same red or similar red-orange color as *A. baumannii*. Their study also reported that CHROMagar *Acinetobacter* was 75% sensitive and 100% specific for *A. baumannii*. Based on their study

result, Akers et. al. advised against the use of CHROMagar Acinetobacter in the absence of confirmatory testing [27].

The study results from Akers et al. was similar to our study result in that MDR-*A. baumannii* was indistinguishable from non-MDR-*A. baumannii* on CHROMagar Acinetobacter by colony color or morphology. In our study, *S. maltophilia*, *P. aeruginosa* and *A. xylosoxidans* grew on CHROMagar Acinetobacter with a similar red color as *A. baumannii* but we did not observe the growth of *E. cloacae* and *S. aureus* as reported by Akers et al. This study also reported a lower sensitivity of CHROMagar Acinetobacter for *A. baumannii* than observed in our study.

CHROMagar Acinetobacter has been recently improved to select for MDR-*Acinetobacter*. Addition of an optional MDR supplement CR102 specifically selects for MDR-resistant strains defined as strains that are resistant to carbapenems. CHROMagar Acinetobacter specifically designed for identification of MDR-*Acinetobacter* was recently evaluated by Wareham et. al. This study reported that the addition of the MDR supplement to CHROMagar Acinetobacter prevented the growth of carbapenem-susceptible *A. baumannii*. However, the authors reported that *S. maltophilia* still grew on CHROMagar Acinetobacter and appeared with a similar red color as *A. baumannii*, making it difficult to distinguish from *A. baumannii* [28].

Excluding the cost of equipment and labor, the cost of CHROMagar Acinetobacter is higher than the cost of sheep blood agar and MacConkey agar. However, there may be additional costs associated with isolation and identification of other bacterial isolates worked up and ultimately found not to be *Acinetobacter* when using sheep blood agar and MacConkey agar. CHROMagar Acinetobacter may save time when the absence of a red color indicates the absence of *Acinetobacter* species in a patient sample. However, a comprehensive time and cost-benefit analysis of using CHROMagar Acinetobacter versus sheep blood agar and MacConkey agar for isolating *Acinetobacter* is beyond the scope of this study. It will be useful for future studies to compare CHROMagar Acinetobacter to other culture media on their time and cost savings.

In summary, our study results and those from prior studies suggest that CHROMagar Acinetobacter is selective for *A. baumannii* but still allows growth of certain other gram-negative bacteria with a similar red color as *A. baumannii*. Even though these other bacteria can be distinguished from *Acinetobacter* by the variation of their red color, colony morphology and oxidase reaction, there is still need for CHROMagar Acinetobacter to better differentiate *A. baumannii* from these other gram-negative bacteria without further testing to confirm *A. baumannii*. CHROMagar Acinetobacter may be a useful media for screening and improving infection control strategies aimed at limiting the spread of MDR-*A. baumannii* if improved upon to better select for MDR-*A. baumannii*. The addition of MDR supplement to CHROMagar Acinetobacter has demonstrated selectivity for carbapenem-resistant *A. baumannii*. However, larger studies in different patient populations are needed to evaluate the performance of CHROMagar Acinetobacter with MDR supplement for screening of MDR-*A. baumannii*. Although a limitation of this study is the small sample size, this study provides useful information on the performance of CHROMagar Acinetobacter when compared to other culture media for detection of *A. baumannii* for surveillance and control of *Acinetobacter* species in critically ill patients.

Acknowledgments

CHROMagar (Paris, France) supplied powdered media for the study and supported previous presentation of this data.

Dr. Harris was supported by National Institutes of Health Midcareer Investigator Award 1K24AI079040 and 2R01AI060859-05. Dr. Furuno was supported by National Institutes of Health Career Development Award 1K01AI071015-03 and Agency for Healthcare Research and Quality Contract Number: HHSA290200600020. Dr. Johnson is supported by National Institutes of Health grant 1K12RR023250-03. AO received travel funds to present this data at the 50th ICAAC, Boston, MA, 2010.

References

1. Sunenshine RH, Wright MO, Maragakis LL, Harris AD, Song X, Hebden J, Cosgrove SE, Anderson A, Carnell J, Jernigan DB, Kleinbaum DG, Perl TM, Standiford HC, Srinivasan A. Multidrug-resistant *Acinetobacter* infection mortality rate and length of hospitalization. *Emerg Infect Dis*. 2007; 13(1):97–103. [PubMed: 17370521]
2. Playford EG, Craig JC, Iredell JR. Carbapenem-resistant *Acinetobacter baumannii* in intensive care unit patients: risk factors for acquisition, infection and their consequences. *J Hosp Infect*. 2007; 65(3):204–211. [PubMed: 17254667]
3. Kwon KT, Oh WS, Song JH, Chang HH, Jung SI, Kim SW, Ryu SY, Heo ST, Jung DS, Rhee JY, Shin SY, Ko KS, Peck KR, Lee NY. Impact of imipenem resistance on mortality in patients with *Acinetobacter* bacteraemia. *J Antimicrob Chemother*. 2007; 59(3):525–530. [PubMed: 17213265]
4. Munoz-Price LS, Weinstein RA. *Acinetobacter* infection. *N Engl J Med*. 2008; 358(12):1271–1281. [PubMed: 18354105]
5. Urban C, Meyer KS, Mariano N, Rahal JJ, Flamm R, Rasmussen BA, Bush K. Identification of TEM-26 beta-lactamase responsible for a major outbreak of ceftazidime-resistant *Klebsiella pneumoniae*. *Antimicrob Agents Chemother*. 1994; 38(2):392–395. [PubMed: 8192474]
6. Kohlenberg A, Brummer S, Higgins PG, Sohr D, Piening BC, de Grahl C, Halle E, Ruden H, Seifert H. Outbreak of carbapenem-resistant *Acinetobacter baumannii* carrying the carbapenemase OXA-23 in a German university medical centre. *J Med Microbiol*. 2009; 58(Pt 11):1499–1507. [PubMed: 19589905]
7. Fontana C, Favaro M, Minelli S, Bossa MC, Testore GP, Leonardi F, Natoli S, Favalli C. *Acinetobacter baumannii* in intensive care unit: a novel system to study clonal relationship among the isolates. *BMC Infect Dis*. 2008; 8:79. [PubMed: 18538034]
8. Lolans K, Rice TW, Munoz-Price LS, Quinn JP. Multicity outbreak of carbapenem-resistant *Acinetobacter baumannii* isolates producing the carbapenemase OXA-40. *Antimicrob Agents Chemother*. 2006; 50(9):2941–2945. [PubMed: 16940085]
9. Heritier C, Dubouix A, Poirel L, Marty N, Nordmann P. A nosocomial outbreak of *Acinetobacter baumannii* isolates expressing the carbapenem-hydrolysing oxacillinase OXA-58. *J Antimicrob Chemother*. 2005; 55(1):115–118. [PubMed: 15590718]
10. Maragakis LL, Cosgrove SE, Song X, Kim D, Rosenbaum P, Ciesla N, Srinivasan A, Ross T, Carroll K, Perl TM. An outbreak of multidrug-resistant *Acinetobacter baumannii* associated with pulsatile lavage wound treatment. *JAMA*. 2004; 292(24):3006–3011. [PubMed: 15613669]
11. Melamed R, Greenberg D, Porat N, Karplus M, Zmora E, Golan A, Yagupsky P, Dagan R. Successful control of an *Acinetobacter baumannii* outbreak in a neonatal intensive care unit. *J Hosp Infect*. 2003; 53(1):31–38. [PubMed: 12495683]
12. Maragakis LL, Tucker MG, Miller RG, Carroll KC, Perl TM. Incidence and prevalence of multidrug-resistant *acinetobacter* using targeted active surveillance cultures. *JAMA*. 2008; 299(21):2513–2514. [PubMed: 18523219]
13. Wise KA, Tosolini FA. Epidemiological surveillance of *Acinetobacter* species. *J Hosp Infect*. 1990; 16(4):319–329. [PubMed: 1980504]
14. Kollef KE, Schramm GE, Wills AR, Reichley RM, Micek ST, Kollef MH. Predictors of 30-day mortality and hospital costs in patients with ventilator-associated pneumonia attributed to potentially antibiotic-resistant gram-negative bacteria. *Chest*. 2008; 134(2):281–287. [PubMed: 18682456]
15. Flayhart D, Hindler JF, Bruckner DA, Hall G, Shrestha RK, Vogel SA, Richter SS, Howard W, Walther R, Carroll KC. Multicenter evaluation of BBL CHROMagar MRSA medium for direct detection of methicillin-resistant *Staphylococcus aureus* from surveillance cultures of the anterior nares. *J Clin Microbiol*. 2005; 43(11):5536–5540. [PubMed: 16272482]

16. Yang HY, Suh JT, Lee HJ. Evaluation of commercial selective agars in screening for methicillin-resistant *Staphylococcus aureus*. *Ann Clin Lab Sci*. 2010; 40(3):252–256. [PubMed: 20689137]
17. Stamper PD, Shulder S, Bekalo P, Manandhar D, Ross TL, Speser S, Kingery J, Carroll KC. Evaluation of BBL CHROMagar VanRE for detection of vancomycin-resistant Enterococci in rectal swab specimens. *J Clin Microbiol*. 2010; 48(11):4294–4297. [PubMed: 20739492]
18. Saito R, Koyano S, Nagai R, Okamura N, Moriya K, Koike K. Evaluation of a chromogenic agar medium for the detection of extended-spectrum-beta-lactamase-producing Enterobacteriaceae. *Lett Appl Microbiol*. 2010; 51(6):704–706. [PubMed: 21117288]
19. Huang TD, Bogaerts P, Berhin C, Guisset A, Glupczynski Y. Evaluation of Brilliance ESB agar, a novel chromogenic medium for detection of extended-spectrum-beta-lactamase-producing Enterobacteriaceae. *J Clin Microbiol*. 2010; 48(6):209–2096.
20. Randall LP, Kirchner M, Teale CJ, Coldham NG, Liebana E, Clifton-Hadley F. Evaluation of CHROMagar CTX, a novel medium for isolating CTX-M-ESBL-positive Enterobacteriaceae while inhibiting AmpC-producing strains. *J Antimicrob Chemother*. 2009; 63(2):302–308. [PubMed: 19043079]
21. Panagea T, Galani I, Souli M, Adamou P, Antoniadou A, Giamarellou H. Evaluation of CHROMagar KPC for the detection of carbapenemase-producing Enterobacteriaceae in rectal surveillance cultures. *Int J Antimicrob Agents*. 2011; 37(2):124–128. [PubMed: 21177079]
22. Clinical and Laboratory Standards Institute. Performance standards for antimicrobial susceptibility testing; nineteenth informational supplement. CLSI; 2009.
23. Thom KA, Hsiao WW, Harris AD, Stine OC, Rasko DA, Johnson JK. Patients with *Acinetobacter baumannii* bloodstream infections are colonized in the gastrointestinal tract with identical strains. *Am J Infect Control*. 2010; 38(9):751–753. [PubMed: 20570393]
24. Morgan DJ, Liang SY, Smith CL, Johnson JK, Harris AD, Furuno JP, Thom KA, Snyder GM, Day HR, Perencevich EN. Frequent multidrug-resistant *Acinetobacter baumannii* contamination of gloves, gowns, and hands of healthcare workers. *Infect Control Hosp Epidemiol*. 2010; 31(7):716–721. [PubMed: 20486855]
25. Jawad A, Hawkey PM, Heritage J, Snelling AM. Description of Leeds Acinetobacter Medium, a new selective and differential medium for isolation of clinically important *Acinetobacter* spp., comparison with Herellea agar and Holton's agar. *J Clin Microbiol*. 1994; 32(10):2353–2358. [PubMed: 7814465]
26. Gordon NC, Wareham DW. Evaluation of CHROMagar Acinetobacter for detection of enteric carriage of multidrug-resistant *Acinetobacter baumannii* in samples from critically ill patients. *J Clin Microbiol*. 2009; 47(7):2249–2251. [PubMed: 19439546]
27. Akers KS, Barsoumian A, Beckius ML, Murray CK, Mende K. CHROMagar Acinetobacter is not selective for carbapenem-resistant *Acinetobacter baumannii* -calcoaceticus complex. *Diagn Microbiol Infect Dis*. 2010; 67(2):209–211. [PubMed: 20466197]
28. Wareham DW, Gordon NC. Modifications to CHROMagar Acinetobacter for improved selective growth of multi-drug resistant *Acinetobacter baumannii*. *J Clin Microbiol*. 2011; 47(7):2249–2251. [PubMed: 19439546]

Fig. 1. Appearance of *Acinetobacter* spp. and other gram-negative bacteria with similar red color as *Acinetobacter* on CHROMagar Acinetobacter media. **a** *Acinetobacter* spp. appeared as bright salmon red colonies. **b** *Pseudomonas* spp. appeared as shiny red colonies and tested oxidase-positive. **c** *Stenotrophomonas* spp. appeared as red-orange pinpoint colonies with clear peripheral edges and tested oxidase-negative. **d** *Achromobacter* spp. appeared as pinpoint dark red colonies and tested oxidase-positive

Table 1

Antibiotic susceptibility profile for MDR-*A. baumannii* isolated using four different culture media

Isolate no.	ORG	IPM	DORI	MER	ERT	SXT	SAM	AMK	GEN	TZP	CIP	CAZ	FEP
26.1	<i>A. baumannii</i>	R	NS	R	R	R	R	S	S	R	R	R	R
35.3	<i>A. baumannii</i>	R	NS	R	R	R	R	R	S	R	R	R	R
40	<i>A. baumannii</i>	R	NS	R	R	R	R	I	R	R	R	R	I
43	<i>A. baumannii</i>	R	NS	R	R	R	R	I	R	R	R	R	I
57.1	<i>A. baumannii</i>	R	NS	R	R	S	R	R	S	R	R	R	R
92	<i>A. baumannii</i>	R	NS	R	R	R	R	R	R	R	R	R	R
112	<i>A. baumannii</i>	R	NS	R	R	R	S	R	S	R	R	R	I
122	<i>A. baumannii</i>	R	NS	R	R	R	R	R	R	R	R	R	R
123.2	<i>A. baumannii</i>	R	NS	R	R	R	R	R	R	R	R	I	R
151.2	<i>A. baumannii</i>	R	NS	R	R	R	I	R	S	R	R	R	I
155	<i>A. baumannii</i>	R	NS	R	R	R	R	R	S	R	R	R	R

IPM imipenem, *DORI* doripenem, *MER* meropenem, *ERT* ertapenem, *SXT* sulfamethoxazole-trimethoprim, *SAM* ampicillin-sulbactam, *AMK* amikacin, *GEN* gentamicin, *TZP* piperacillin tazobactam, *CIP* ciprofloxacin, *CAZ* ceftazidime, *FEP* ceftazidime, *MIC* minimum inhibitory concentration, *R* resistant, *S* susceptible, *NS* not susceptible, *I* intermediate