Introduction

Tuberculosis (TB) remains a public health problem in many countries around the world. Although efforts have been made to eliminate this airborne disease, new cases of TB infection are still on the rise in some countries. According to a WHO report, there are 20 million cases of TB worldwide, with 8 million new cases and 3 million deaths each year. One of the most critical aspects of TB control is rapid identification of infectious patients (American Thoracic Society, 1997; WHO, 2003). Although there are commercially available kits for rapid detection of DNA of members of the Mycobacterium tuberculosis complex (MTBC), culture is still needed to confirm the presence of live MTBC from a suspected patient’s specimen as well as for drug susceptibility testing (Kent & Kubic, 1985; American Thoracic Society, 1997). The BACTEC radiometric method using the BACTEC460 TB system is one of the rapid methods used for culture of mycobacteria. Identification using the BD ProbeTec ET system (Becton Dickinson Diagnostic Instruments) was performed according to the manufacturer’s instructions using BACTEC460 TB system for identification of MTBC isolates from BACTEC 12B culture vials was evaluated in comparison with BACTEC NAP (p-nitro-\(\alpha\)-acetylamino-\(\beta\)-hydroxy-propiophenone) differentiation. Of 145 mycobacterial isolates tested, comprising 89 MTBC and 56 non-tuberculous mycobacteria (NTM), BD ProbeTec ET correctly identified 87 MTBC and 56 NTM but missed two MTBC. Three NTM were misidentified when NAP was incubated at 37 °C only. Overall sensitivity, specificity and positive and negative predictive values were respectively 97.8, 100, 100 and 96.6 % for the BD ProbeTec ET system and 100, 94.6, 96.7 and 94.6 % for NAP.

The objective of this study was to compare the sensitivity and specificity of the BD ProbeTec ET system with the existing NAP method for identification of MTBC isolates from BACTEC 12B culture vials.

Methods

Specimens used were 140 clinical specimens sent to our laboratory for mycobacterial culture and five mycobacteriology survey specimens from the College of American Pathologists (CAP 2000EB). Altogether, there were 103 respiratory specimens (92 sputum, five bronchial wash, three laryngeal swab and three gastric fluid) and 42 non-respiratory specimens (23 tissue, three pleural fluid, five wound swab, four pus, three blood, two urine and one each for cerebrospinal fluid and body fluid). Samples were processed by the NaOH digestion/decontamination procedure using 4 % NaOH (Petroff, 1915). After centrifugation, one or two drops of phenol red indication solution were added to each sediment, which was neutralized by adding 2 M HCl dropwise until the colour of the sediment turned from red to yellow. The sediment was then resuspended in 1 ml phosphate buffer (pH 6.8). An aliquot (0.5 ml) of processed specimen was inoculated into a BACTEC 12B culture vial supplemented with 0.1 ml antimicrobial mixture. Culture vials were then incubated at 37 °C. BACTEC 12B cultures showing a minimum growth index (GI) of ≥50 were investigated. An acid-fast bacilli (AFB) smear was performed and, if positive, the NAP identification test was carried out using a standard method (Siddiqi, 1995). NAP-differentiated MTBC isolates from non-respiratory specimens and MTBC isolates from respiratory specimens from patients without known MTBC isolation within the last 12 months were confirmed by a DNA probe for MTBC (AccuProbe). Each culture-positive isolate that was differentiated as a non-tuberculous mycobacterium (NTM) by NAP was subcultured on solid medium and identified to the species level using conventional biochemical tests and commercial DNA probes for Mycobacterium kansasii, Mycobacterium avium complex and Mycobacterium gordonae (AccuProbe).

Identification using the BD ProbeTec ET system (Becton Dickinson Diagnostic Instruments) was performed according to the manufac-
turer’s instructions. Briefly, when the GI of a 12B vial reached 500 or above, 500 μl of a well-mixed culture was added to 1 ml wash buffer in a centrifuge tube, vortexed for 5 s and centrifuged at 12 200 g for 3 min. The pellet was heated for 30 min at 105 °C to render the organisms non-viable. After being pulse-centrifuged for 10 s, the pellet was resuspended in 100 μl lysis buffer, vortexed for 5 s and placed in a 65 °C sonic water bath (Branson Ultrasonic) for 45 min. The sonicated sample was pulse-centrifuged for 10 s, followed by addition of 600 μl neutralization buffer. The mixture was then vortexed for 5 s, pulse-centrifuged for 10 s and tested immediately. For each BD ProbeTec ET assay, one positive and one negative control were included. A known MTBC strain, ATCC 27294 T, was also included as a sample processing control. In addition, four clinical specimens (three pleural fluid, one lung biopsy) with negative AFB culture results were tested by BD ProbeTec ET assay. Using an eight-channel pipettor and aerosol-resistant tips, 150 μl of each sample or control was dispensed into a priming microwell. The priming microwell plate was covered and incubated at room temperature for 30 min before being placed into a 72.5 °C heating block. After incubation at 72.5 °C for 10 min, 100 μl from each priming microwell was transferred to the corresponding amplification microwell, which had been prewarmed in a 54 °C heating block for 10 min. The amplification microwells were then sealed and placed immediately in the BD ProbeTec ET instrument for 60 min. Samples with MTBC MOTA (metric other than acceleration) values greater than 7000 were considered positive for MTBC, regardless of the internal amplification control (IAC) MOTA. If the MTBC MOTA was less than 7000 and the IAC MOTA was greater than 5000, the result was considered indeterminate and the processed sample was tested again. If the NAP and BD ProbeTec ET System results were discordant, a frozen aliquot of the discrepant sample was tested again on the NAP and BD ProbeTec ET System. Three NTM from tissue samples were best grown at approximately 30 °C (Table 1). Further investigation found that the three samples were best grown at approximately 30 °C and needed haemin to grow. A repeat NAP test on the cultures incubated at 30 °C identified the three samples as NTM, and final identification results suggested M. haemophilum. DNA probes for MTBC were negative for the three samples. Two MTBC were not detected by BD ProbeTec ET. One of the two was isolated from tissue and the other was from a laryngeal swab. The two MTBC cultures were retested by BD ProbeTec ET but showed reproducible negative results. MTBC and IAC MOTA values were respectively 144 and 21157 and 134 and 55372 for the tissue and laryngeal swab; as the IAC data showed no evidence of inhibition, these two specimens should be regarded as true false-negatives that might be due to mutation of the target gene. Cultures from the original BACTEC 12B vials were positive for MTBC by DNA probe. Overall sensitivity, specificity and positive and negative predictive values were respectively 97-8, 100, 100 and 96-6 % for BD ProbeTec ET and 100, 94-6, 96-7 and 94-6 % for NAP. Four clinical specimens (three pleural fluid, one lung biopsy) with negative AFB culture results tested by BD ProbeTec ET were negative.

Methodological culture using the BACTEC460 TB system is one of the rapid methods for isolation of MTBC from patients with suspected TB. The low-cost BACTEC NAP method, though outdated and with certain restrictions (Siddiqi, 1995), is still being used for differentiation of MTBC from NTM in some laboratories. As NAP alone is not good enough for identification of MTBC isolates, an equivalent molecular target approach such as Gen-Probe, Roche Amplicor PCR assay, ligase chain reaction or enhanced amplified direct test may be introduced for confirmation, especially for MTBC isolated from non-respiratory specimens and patients with unknown MTBC infection. The reported sensitivities for the molecular methods range from 87 to 100 %, and all achieve 100 % specificity (Reisner et al., 1994; Smith et al., 1997; Tortoli et al., 1998; Bergmann & Woods, 1999). However, the high cost of performing molecular tests is a disadvantage. A few publications have recently reported that rapid diagnosis of MTBC in pulmonary and extrapulmonary specimens by the BD ProbeTec ET System showed sensitivity ranging from 77-8 to over 90 % and specificity of 99-5 to 99-8 % (Bergmann et al., 2000; Piersimoni et al., 2002; Mazzarelli et al., 2003). As for culture confirmation, not enough study data were available. Our data showed that the BD ProbeTec ET system, which is from the manufacturer of BACTEC460 TB system, is a possible alternative method for rapid identification of MTBC from positive BACTEC vials. During the evaluation period, we found that the BD ProbeTec ET system is easy to use and can perform up to 96 identification tests in one run; sensitivity and specificity for differentiation of MTBC from NTM are satisfactory. The BD ProbeTec ET differentiation procedure is less labour-intensive and more efficient than NAP. Identification by the BD ProbeTec ET system can be completed within 1 working day, whereas NAP needs 4–8 days. All reagents used in the BD ProbeTec ET system may be stored at room temperature and, therefore, no refrigeration or freezing is required.

Results and Discussion

Of the 145 positive AFB isolates studied, comprising 89 MTBC and 56 NTM (24 M. avium complex, 13 M. kansasii, five M. gordonae, three Mycobacterium haemophilum, two each of Mycobacterium fortuitum and Mycobacterium chelonae, one Mycobacterium scrofulaceum and six unidentifiable NTM), 87 MTBC and 56 NTM were identified correctly by NAP and BD ProbeTec ET. Three NTM from tissue samples were misidentified as MTBC by NAP initially while incubating the cultures incubated at 30 °C (Table 1). Further investigation found that the three samples were best grown at approximately 30 °C and needed haemin to grow. A repeat NAP test on the cultures incubated at 30 °C identified the three samples as NTM, and final identification results suggested M. haemophilum. DNA probes for MTBC were negative for the three samples. Two MTBC were not detected by BD ProbeTec ET. One of the two was isolated from tissue and the other was from a laryngeal swab. The two MTBC cultures were retested by BD ProbeTec ET but showed reproducible negative results. MTBC and IAC MOTA values were respectively 144 and 21157 and 134 and 55372 for the tissue and laryngeal swab; as the IAC data showed no evidence of inhibition, these two specimens should be regarded as true false-negatives that might be due to mutation of the target gene. Cultures from the original BACTEC 12B vials were positive for MTBC by DNA probe. Overall sensitivity, specificity and positive and negative predictive values were respectively 97-8, 100, 100 and 96-6 % for BD ProbeTec ET and 100, 94-6, 96-7 and 94-6 % for NAP. Four clinical specimens (three pleural fluid, one lung biopsy) with negative AFB culture results tested by BD ProbeTec ET were negative.

Table 1. Identification of AFB-positive isolates by NAP and BD ProbeTec ET

<table>
<thead>
<tr>
<th>Parameter</th>
<th>NAP</th>
<th>BD ProbeTec ET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive AFB isolates (n):</td>
<td>MTBC (n = 89)</td>
<td>92*</td>
</tr>
<tr>
<td></td>
<td>NTM (n = 56)</td>
<td>53</td>
</tr>
<tr>
<td>Sensitivity (%)</td>
<td>100</td>
<td>97-8</td>
</tr>
<tr>
<td>Specificity (%)</td>
<td>94-6</td>
<td>100</td>
</tr>
<tr>
<td>Positive predictive value (%)</td>
<td>96-7</td>
<td>100</td>
</tr>
<tr>
<td>Negative predictive value (%)</td>
<td>94-6</td>
<td>96-6</td>
</tr>
</tbody>
</table>

*Including three MTBC isolates misidentified by NAP at 37 °C.
In summary, our study suggests that the BD ProbeTec ET system is reliable for identification of MTBC isolates in conjunction with the BACTEC460 TB system. It provides shorter turnaround times and better specificity than BACTEC NAP. However, as the number of isolates included in our study was small, it will be useful to conduct further studies to confirm our findings.

Acknowledgements
The authors wish to thank Becton Dickinson (Singapore) Pty Ltd for providing BD ProbeTec ET equipment and reagent kits and Ms Hla Hla Htay for her assistance during this study.

References


