



A Cost-Effective Capillary Tube Method for Gram Staining: A Comparative Study with Conventional Slide Technique

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Gram staining (GS) is widely used for rapid visualization and determination of bacteria based on cell wall characteristics, classifying them as Gram-positive or Gram-negative. The conventional slide-based technique requires multiple reagents, including ammonium oxalate-crystal violet, Lugol's iodine, acetone-iodine, and dilute carbol fuchsin, often in relatively high volumes. This study aimed to introduce a novel capillary tube-based GS method to significantly reduce reagent usage and offer a cost-effective alternative method while maintaining accuracy. The capillary tube method (CTM) and the conventional glass slide method (GSM) were performed on selected control strains and clinical isolates. A small volume of bacterial suspension was drawn into a capillary tube, heat-fixed, and Gram-stained after natural cooling. The crystal violet and Gram's iodine steps were extended to one minute to optimize staining. Stained capillary tubes were evaluated using eight scoring variables. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated. A chi-square test was applied for data analysis using SPSS. Cost and turnaround time per assay were also estimated. There was no statistically significant difference about uniformity of background staining between the two methods ($p=0.825$), with a sensitivity of 88.9%, specificity of 20%, PPV of 90.9%, and NPV of 16.7%. Similarly, the presence of staining artifacts was not statistically significant between methods ($p=0.064$), with a sensitivity of 70%, specificity of 62.5%, PPV of 31.8%, and NPV of 89%. Hence, no significant difference was observed between CTM and GSM. The CTM was the most cost-effective method while GS required less processing time. The CTM offers a cost-effective alternative to the conventional GSM without compromising staining quality or diagnostic reliability, making it suitable for resource-limited laboratory settings.

Keywords: Bacteria, Capillary tube method, Glass slide method, Gram staining