

# Phenotypic Detection of Inducible Ampc Beta-Lactamase Producing Gram Negative Bacilli from Tertiary Care Center

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## Introduction

The rise of bacterial resistance to antimicrobial agents remains a significant challenge in clinical medicine. Over recent years, numerous antimicrobial classes have seen diminished effectiveness due to the evolution of microbial resistance mechanisms. In many instances, this trend has been associated with the widespread and prolonged use of selective antimicrobial drugs. Particularly in hospital-acquired infections, resistance continues to pose a serious threat to the success of modern antimicrobial therapies.<sup>[1]</sup> Bacteria that possess chromosomally encoded inducible AmpC beta-lactamases present particularly challenges for antibiotic susceptibility reporting. In vitro susceptibility may not correlate with clinical efficacy as resistance can emerge by selection of mutants expressing high levels of AmpC. This has been best described in the context of *Enterobacter* bacteraemia and therapy with third-generation cephalosporins<sup>[2]</sup>. Bacteria harboring chromosomally encoded inducible AmpC  $\beta$ -lactamases pose a major obstacle in clinical microbiology due to their impact on antimicrobial susceptibility interpretation and therapeutic decision-making. In vitro

susceptibility results may not accurately reflect clinical outcomes, as resistance can emerge in vivo through the selection of mutants overexpressing AmpC. This has been most clearly demonstrated in *Enterobacter* bacteraemia treated with third-generation cephalosporins<sup>[3]</sup>. AmpC  $\beta$ -lactamases confer resistance to many  $\beta$ -lactams; however, this resistance may sometimes be overcome by fourth-generation cephalosporins or alternative therapeutic agents, including carbapenems, aminoglycosides, and fluoroquinolones.

AmpC induction is regulated by key genes such as AmpD and AmpG, which are involved in the intracellular recycling of peptidoglycan fragments<sup>[4]</sup>. Experimental evidence indicates that regulatory binding upstream of the AmpC gene is not easily demonstrated, suggesting additional complexity in its regulation<sup>[5]</sup>. The degree of AmpC induction depends on both the  $\beta$ -lactam inducer and its concentration. Cefoxitin is a well-documented potent inducer of AmpC in *Enterobacter cloacae*, *Citrobacter freundii*, and *Enterobacter aerogenes*. Furthermore, carbapenems

## Phenotypic Detection Of Inducible AmpC Beta-Lactamase Producing Gram Negative Bacilli From Tertiary Care Center

such as imipenem and meropenem may act as equally strong inducers of AmpC, particularly in *C. freundii*. Aminopenicillins and cephamycins also act as strong inducers and are efficiently hydrolyzed by these enzymes in Gram-negative bacilli<sup>[6]</sup>

Despite the clinical significance of AmpC  $\beta$ -lactamase-producing organisms, there remains a significant knowledge gap in routine detection, as most laboratories focus on ESBLs while neglecting AmpC detection. Standard antimicrobial susceptibility testing frequently fails to differentiate inducible AmpC producers from other resistance mechanisms, risking therapeutic failure and inappropriate antimicrobial regimens. Moreover, the prevalence and phenotypic distribution of inducible AmpC  $\beta$ -lactamase producing Gram-negative bacilli varies across regions and health care settings, with systematic data limited from tertiary care centers in many parts of the world<sup>[7]</sup>. Addressing this gap is critical for both epidemiological understanding and the development of effective infection control strategies. Utilizing and evaluating reliable phenotypic methods—such as the cefoxitin-based screening followed by confirmatory approaches like the disc approximation test, cefoxitin-cloxacillin double disc synergy test (CC-DDS), phenylboronic acid method, and TRIS-EDTA method—are essential for routine practice in tertiary care centers<sup>[8]</sup>

Given these challenges, phenotypic detection of inducible AmpC  $\beta$ -lactamase producers is critical in guiding appropriate antimicrobial therapy, especially in tertiary care settings where multidrug-resistant Gram-negative bacilli are frequently encountered.

### Aims and Objectives

- 1) To isolate and identify gram negative bacilli from clinical samples and to determine its antibiotic resistance pattern.
- 2) To detect Inducible AmpC Beta-lactamase producers by Cefoxitin Screening Test, Disk Antagonism Test, and a confirmatory Boronic Acid and Cloxacillin Combination Disk Diffusion Test.

### Materials and Methods

This cross-sectional study was conducted over a six-month period from February 2024 to July 2024 in the Department of Microbiology at Vinayaka Mission's Kirupananda Variyar Medical College and Hospitals, Salem. A total of 100 clinical samples were included, comprising specimens such as blood, urine, pus, sputum, stool, throat swabs, and other body fluids. All

samples were collected under strict aseptic conditions in sterile containers and immediately transported for processing. Specimens were inoculated on MacConkey agar and Blood agar media and incubated at 35°C for 18–24 hours.

Isolates were identified using standard microbiological techniques, including colony morphology, Gram staining, and biochemical tests such as the Indole test, Urease test, Citrate utilization test, Triple Sugar Iron (TSI) test, and Mannitol motility media. Antimicrobial susceptibility testing was performed using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar, with results interpreted according to Clinical and Laboratory Standards Institute (CLSI) guidelines<sup>[6]</sup>. Antibiotic disks used included Ampicillin (10  $\mu$ g), Amoxy-clavulanate (20  $\mu$ g + 10  $\mu$ g), Amikacin (30  $\mu$ g), Cefepime (30  $\mu$ g), Cefoperazone-sulbactam (75  $\mu$ g), Cefotaxime (30  $\mu$ g), Ciprofloxacin (5  $\mu$ g), Cotrimoxazole (25  $\mu$ g), Doxycycline (30  $\mu$ g), Fosfomycin (200  $\mu$ g), Gentamicin (10  $\mu$ g), Imipenem (10  $\mu$ g), Levofloxacin (5  $\mu$ g), Meropenem (10  $\mu$ g), Piperacillin/Tazobactam (10  $\mu$ g), Tigecycline (15  $\mu$ g), Cefoxitin (30  $\mu$ g), and Ceftazidime (30  $\mu$ g).

**Inclusion criteria** encompassed patients of all age groups with Gram-negative bacilli resistant to cefoxitin. **Exclusion criteria** included Gram-positive organisms and isolates susceptible to cefoxitin.

For Phenotypic detection of Inducible AmpC  $\beta$ -lactamase, all Gram-negative bacilli isolates resistant to cefoxitin were subjected to phenotypic characterization for inducible AmpC  $\beta$ -lactamase production using the Cefoxitin Screening Test, Disk Antagonism Test, and a confirmatory Boronic Acid and Cloxacillin Combination Disk Diffusion Test. For Cefoxitin Screening Test, Isolates exhibiting a zone diameter of  $\leq 18$  mm around the cefoxitin (30  $\mu$ g) disk on Mueller-Hinton agar were considered positive for potential AmpC production, as per established criteria<sup>[9]</sup>. Disk Antagonism Test was performed by placing an inducer disk (cefoxitin, imipenem, or amoxicillin-clavulanate) at the center of a Mueller-Hinton agar plate, with substrate disks (cefotaxime or ceftazidime) positioned 20 mm away from the inducer. Plates were incubated overnight at 37°C. A positive result was indicated by blunting of the inhibition zone of the substrate disk toward the inducer disk, forming a characteristic "D-shaped" distortion. For Confirmatory Test, Boronic Acid and Cloxacillin Combination Disk

## Phenotypic Detection Of Inducible Ampc Beta-Lactamase Producing Gram Negative Bacilli From Tertiary Care Center

Diffusion Test was employed. A lawn culture of the test organism, adjusted to 0.5 McFarland turbidity, was inoculated on Mueller-Hinton agar using the Kirby-Bauer method. Three disks were placed 20 mm apart: (1) ceftiofur (30 µg), (2) ceftiofur impregnated with 300 µg phenylboronic acid, and (3) ceftiofur impregnated with cloxacillin. After overnight aerobic incubation at 35–37°C, an increase in zone diameter of ≥5 mm around the ceftiofur-boronic acid and ceftiofur-cloxacillin disks compared to the ceftiofur disk alone was interpreted as a positive result for AmpC β-lactamase production.<sup>[9]</sup>

Data were analyzed using IBM SPSS Statistics version 26.0. Descriptive statistics were used to determine the proportion of isolates testing positive by each phenotypic method. A Venn diagram was constructed to illustrate the overlap in positivity among the Ceftiofur Screening Test, Disk Antagonism Test, and Boronic Acid + Cloxacillin Test. To evaluate whether the proportion of positive results differed significantly across the three methods, Cochran's Q test was applied to the binary outcome data. Kappa statistics were also calculated to assess inter-test agreement. All statistical tests were two-tailed, and a p-value < 0.05 was considered statistically significant.

### Results

A total of 100 Gram-negative bacilli were isolated from clinical specimens, including endotracheal tube, blood, urine, pus, sputum, stool, throat swabs, and other body fluids. [Table 1]

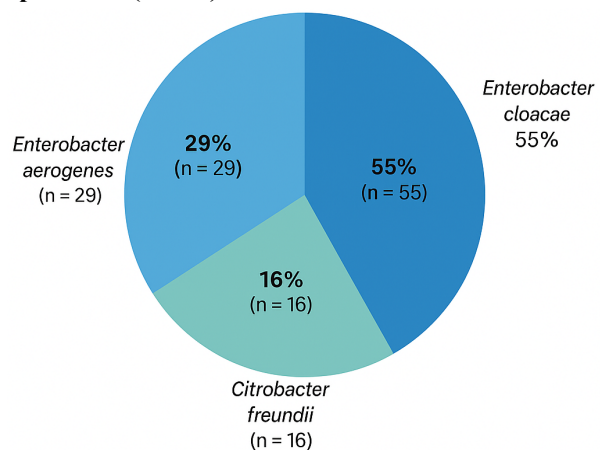
**Table 1: Distribution of Gram-Negative Bacilli Isolates by Specimen Type, Associated Disease Condition and Organism (n=100)**

Specimen	Associated Disease Condition	Enterobacter cloacae	Enterobacter aerogenes	Citrobacter freundii
Blood (n=20)	Septicemia, bacteremia, endocarditis	6 (30%)	14 (70%)	0 (0%)
Urine (n=25)	Urinary tract infection, pyelonephritis	20 (80%)	0 (0%)	5 (20%)

Pus (n=18)	Skin and soft tissue infections, abscesses, wound infections	11 (61%)	7 (39%)	0 (0%)
Sputum (n=12)	Pneumonia, bronchitis	9 (75%)	0 (0%)	3 (25%)
Stool (n=8)	Gastroenteritis, enteric fever	0 (0%)	0 (0%)	8 (100%)
Throat Swab (n=10)	Pharyngitis, tonsillitis	6 (60%)	4 (40%)	0 (0%)
Other Body Fluids (n=7)	Peritonitis, meningitis, pleural effusion	3 (43%)	4 (57%)	0 (0%)
<b>Total</b>		<b>55 (55%)</b>	<b>29 (29%)</b>	<b>16 (16%)</b>

Among these, *Enterobacter cloacae* were the most frequently isolated organism (n = 55), followed by *Enterobacter aerogenes* (n = 29) and *Citrobacter freundii* (n = 16) [Figure 1].

**Figure 1: Distribution of Predominant Gram-Negative Bacilli Isolated from Clinical Specimens (n=100)**



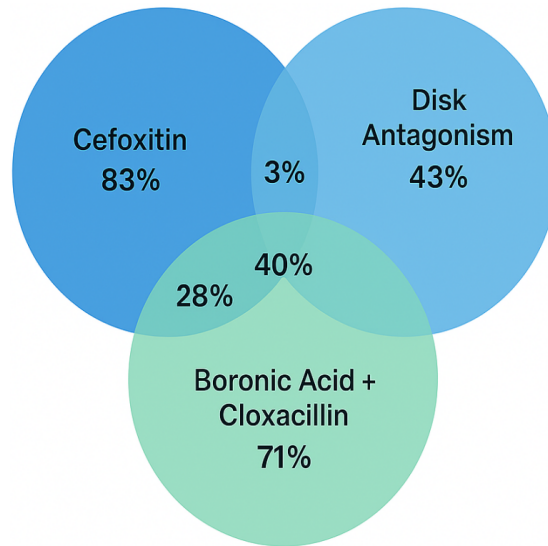
Ceftiofur Screening Test identified a high proportion of potential AmpC producers, with positivity rates of 87.27% (n=48) in *Enterobacter cloacae*, 79.31% (n=23) in *Enterobacter aerogenes*, and 75.00% (n=12) in *Citrobacter freundii*. The Disk Antagonism Test

## Phenotypic Detection Of Inducible Ampc Beta-Lactamase Producing Gram Negative Bacilli From Tertiary Care Center

showed lower detection rates, with 52.73% (n=29) positivity in *E. cloacae*, 27.59% (n=8) in *E. aerogenes*, and 37.50% (n=6) in *C. freundii*. The Boronic Acid and Cloxacillin Combination Disk Diffusion Test confirmed AmpC production in 72.73% (n=40) of *E. cloacae*, 65.52% (n=19) of *E. aerogenes*, and 75.00% (n=12) of *C. freundii* isolates. These findings underscore that *Enterobacter* species and *Citrobacter freundii* are significant contributors to AmpC-mediated resistance. [Table 2]

test may serve as a more specific and confirmatory method, especially when used alongside cefoxitin-based screening. Figure 2 shows Venn diagram illustrating the overlap in positivity among the Cefoxitin Screening Test, Disk Antagonism Test, and Boronic Acid + Cloxacillin Test.

**Figure 2: Venn diagram showing the overlap in positivity rates (n=100)**



Among the 100 clinical isolates evaluated, the Cefoxitin Screening Test demonstrated the highest positivity rate for AmpC β-lactamase production (83%), followed by the Boronic Acid + Cloxacillin Test (71%) and the Disk Antagonism Test (43%). [Table 3]

**Table 2: Resistance Profiling of Enterobacter cloacae, E. aerogenes, and C. freundii Using Phenotypic Methods (n=100)**

S. No	Organism	Total Isolates (n)	Cefoxitin Screening Test (Positive, %)	Disk Antagonism Test (Positive, %)	Boronic Acid + Cloxacillin Test (Positive, %)
1	<i>Enterobacter cloacae</i>	55	48 (87.27%)	29 (52.73%)	40 (72.73%)
2	<i>Enterobacter aerogenes</i>	29	23 (79.31%)	8 (27.59%)	19 (65.52%)
3	<i>Citrobacter freundii</i>	16	12 (75.00%)	6 (37.50%)	12 (75.00%)

**Table 3: Summary of Positive Results and Shared Detection Among AmpC Tests (n=100)**

Phenotypic tests	Overall (n=100)	<i>E. cloacae</i> (n=55)	<i>E. aerogenes</i> (n=29)	<i>C. freundii</i> (n=16)
Cefoxitin only	83 (83%)	46 (83.6%)	24 (82.8%)	13 (81.2%)
Disk Antagonism only	43 (43%)	24 (43.6%)	12 (41.4%)	7 (43.8%)
Boronic Acid + Cloxacillin only	71 (71%)	39 (70.9%)	21 (72.4%)	11 (68.8%)
Cefoxitin & Disk Antagonism overlap	3 (3%)	2 (3.6%)	1 (3.4%)	0 (0%)

The Cefoxitin Screening Test emerged as the most sensitive method for detecting inducible AmpC β-lactamase across all tested organisms, with *Enterobacter cloacae* showing the highest positivity at 87.27%. This reinforces its utility as a reliable initial screening tool. In contrast, the Disk Antagonism Test demonstrated markedly lower detection rates, particularly in *Enterobacter aerogenes* (27.59%), indicating limited sensitivity and potential challenges in interpreting subtle zone differences. The Boronic Acid and Cloxacillin Combination Disk Diffusion Test showed improved performance, with *Citrobacter freundii* exhibiting a 75% positivity rate—closely mirroring the Cefoxitin results. This suggests that the combination

## Phenotypic Detection Of Inducible Ampc Beta-Lactamase Producing Gram Negative Bacilli From Tertiary Care Center

Cefoxitin & Boronic Acid + Cloxacillin	28 (28%)	15 (27.3%)	8 (27.6%)	5 (31.2%)
Disk Antagonism & Boronic Acid + Cloxacillin	40 (40%)	22 (40.0%)	12 (41.4%)	6 (37.5%)

Statistical analysis using Cochran's Q test revealed a significant difference in detection rates among the three methods ( $Q = 42.67$ ,  $df = 2$ ,  $p < 0.001$ ), indicating variability in test sensitivity. Agreement analysis using Fleiss' Kappa yielded a value of  $\kappa = 0.56$ , suggesting moderate concordance across the assays.[Table 4]

**Table 4: Comparison of Positivity Rates Across All Isolates using Cochran's Q test (n=100)**

Test	Positive Cases (n)	Positivity Rate (%)	Fleiss $\kappa$	Cochran's Q	p-Value
Cefoxitin Screening Test	83 / 100	83%	0.56	42.67	< 0.001*
Disk Antagonism Test	43 / 100	43%			
Boronic Acid + Cloxacillin Test	71 / 100	71%			
*p-value < 0.05 taken as significant					

These findings highlight the superior sensitivity of the Cefoxitin and Boronic Acid-based tests compared to the Disk Antagonism method and underscore the importance of employing multiple confirmatory approaches for reliable AmpC detection.

### Discussion

This study underscores the diagnostic variability in phenotypic detection of inducible AmpC  $\beta$ -lactamase among *Enterobacter cloacae*, *Enterobacter aerogenes*, and *Citrobacter freundii* isolates. The Cefoxitin Screening Test showed the highest detection rate (87.27% in *E. cloacae*), consistent with its utility as a primary screening tool. However, its limited specificity necessitates confirmatory testing. The Disk Antagonism Test yielded lower sensitivity, particularly

for *E. aerogenes* (27.59%), which may reflect challenges in interpreting subtle zone differences. In contrast, the Boronic Acid and Cloxacillin Combination Disk Diffusion Test demonstrated improved sensitivity and specificity, detecting AmpC production in 65–75% of isolates.

These findings align with those of Peter-Getzlaff et al.<sup>[10]</sup> in 2011, who compared three phenotypic assays in *Escherichia coli* and found that cefoxitin-based tests, including cefoxitin-cloxacillin and cefoxitin-boronic acid combinations, correctly identified over 90% of AmpC producers. Their study emphasized that cefoxitin resistance was a reliable indicator, though not definitive without confirmatory testing.

Similarly, Roberts et al.<sup>[11]</sup> in 2024, investigated AmpC  $\beta$ -lactamase prevalence in Southeast Asia and found that 97.7% of AmpC-positive *E. coli* and *K. pneumoniae* isolates were resistant to cefoxitin. They highlighted the underreporting of AmpC due to limited routine testing and advocated for phenotypic screening followed by molecular confirmation.

In the Indian context, Cugati and Lyra<sup>[12]</sup> in 2019, evaluated various inducer-substrate combinations and found that cefoxitin with boronic acid and imipenem/piperacillin-tazobactam combinations were effective in detecting both constitutive and inducible AmpC producers. Their study reported a 30% overall AmpC positivity among Enterobacteriaceae, with *Enterobacter* spp. being the most common producers. Taken together, these studies reinforce the need for a multi-tiered phenotypic approach in resource-limited settings. While molecular assays remain the gold standard, optimized phenotypic algorithms—especially those incorporating boronic acid inhibitors—can significantly enhance diagnostic accuracy.

Focusing on *Enterobacter* species, a Malaysian study by Mohd Khari et al.<sup>[13]</sup> (2016) assessed 117 clinical *Enterobacter* isolates, finding a 94.9% positivity by cefoxitin disk screening and confirmatory detection rates of 89.2% with the D69C AmpC detection set and 80.2% with the cefoxitin-cloxacillin double disk synergy test (CC-DDS). However, they noted discordance between phenotypic and genotypic detection, suggesting the complexity of AmpC expression and detection.

Regarding *Citrobacter freundii*, Ruppé et al.<sup>[14]</sup> (2006) reported the first detection of the AmpC-type Ambler class C 1 (ACC-1)  $\beta$ -lactamase, proposing a

## Phenotypic Detection Of Inducible Ampc Beta-Lactamase Producing Gram Negative Bacilli From Tertiary Care Center

cefoxitin-based double-disk synergy test tailored for detection of plasmid-mediated AmpC in chromosomally encoded species like *Citrobacter*. Furthermore, several studies have underscored the role of *Citrobacter freundii* as a reservoir of AmpC  $\beta$ -lactamase genes contributing to multidrug resistance (El-Hady et al., 2015; Joji et al., 2021)<sup>[15,16]</sup>

The Cefoxitin Screening Test is widely recognized for its high sensitivity but relatively moderate specificity in detecting AmpC  $\beta$ -lactamase producers. Polsfuss et al.<sup>[17]</sup> (2011) reported a sensitivity of 97.4% and specificity of 78.7% using cefoxitin disk screening among Enterobacteriaceae isolates. Similarly, Mohd Khari et al.<sup>[13]</sup> (2016) found 94.9% sensitivity in *Enterobacter* isolates. These studies highlight cefoxitin as an excellent initial screening marker, though its lower specificity can yield false positives necessitating confirmatory testing. The Disk Antagonism Test, which evaluates the interaction between cefoxitin and extended-spectrum cephalosporin inhibition zones, is reported to have highly variable sensitivity ranging from moderate to low. Peter-Getzlaff et al.<sup>[10]</sup> (2011) and others have found this method to be less sensitive, particularly in *Enterobacter aerogenes* and *Citrobacter freundii*, due to difficulties in interpreting subtle zone differences. Its specificity tends to be higher but is often compromised by operator subjectivity. The Boronic Acid and Cloxacillin Combination Disk Diffusion Test demonstrates improved specificity and sensitivity for AmpC detection. Polsfuss et al.<sup>[17]</sup> (2011) reported a sensitivity of 97.2% and specificity of 100% for the cefoxitin-cloxacillin double-disk synergy (CC-DDS) confirmation. Boronic acid has also been found to be a highly effective AmpC inhibitor with sensitivity and specificity values often exceeding 90% (Tan et al., 2009), though false positives may occur in the presence of class A carbapenemases<sup>[18]</sup>. Boronic acid-based tests enable reliable differentiation of AmpC producers, especially when combined with initial cefoxitin screening.

### Study Limitations

This study has several limitations that warrant consideration. First, the reliance on phenotypic methods alone may have led to under- or overestimation of AmpC  $\beta$ -lactamase production, as these assays can be influenced by factors such as inoculum density, incubation conditions, and co-expression of other resistance mechanisms (e.g., ESBLs or

carbapenemases). Molecular confirmation of AmpC genes was not performed, which limits the ability to validate phenotypic findings and distinguish between chromosomal and plasmid-mediated AmpC producers. Additionally, the sample size for certain organisms, particularly *Citrobacter freundii* (n = 16), was relatively small, potentially affecting statistical power and generalizability. The study also did not stratify isolates by specimen type or clinical source, which may influence resistance profiles and test performance. Finally, inter-observer variability in interpreting disk-based assays was not assessed, which could impact reproducibility. Future studies incorporating genotypic methods and larger, stratified isolate collections are needed to refine detection strategies and validate phenotypic test accuracy.

### Conclusion:

The study demonstrates that while the Cefoxitin Screening Test offers high sensitivity for detecting inducible AmpC  $\beta$ -lactamase, confirmatory tests like the Boronic Acid and Cloxacillin Combination Disk Diffusion Test provide greater diagnostic reliability. The Disk Antagonism Test showed limited sensitivity and may not be suitable as a standalone method. Integrating multiple phenotypic assays enhances detection accuracy, especially in resource-constrained settings. Early identification of AmpC producers is essential for guiding appropriate antimicrobial therapy and curbing resistance spread.

### References

1. Jones RN, Baquero F, Privitera G, Inoue M, Wiedemann B. Inducible  $\beta$ -lactamase-mediated resistance to third-generation cephalosporins. Clin Microbiol Infect [Internet] 1997 [cited 2025 Aug 6];3:S7–20. Available from: <https://www.sciencedirect.com/science/article/pii/S1198743X14642488>
2. Harris PNA, Ferguson JK. Antibiotic therapy for inducible AmpC  $\beta$ -lactamase-producing Gram-negative bacilli: what are the alternatives to carbapenems, quinolones and aminoglycosides? Int J Antimicrob Agents 2012;40(4):297–305.
3. Ambler RP. The structure of beta-lactamases. Philos Trans R Soc Lond B Biol Sci 1980;289(1036):321–31.
4. Ghuyssen JM, Hakenbeck R. Bacterial cell wall. Amsterdam; Elsevier; 1994.
5. Kohlmann R, Bähr T, Gatermann SG. Species-specific mutation rates for ampC derepression in

## Phenotypic Detection Of Inducible Ampc Beta-Lactamase Producing Gram Negative Bacilli From Tertiary Care Center

- Enterobacterales with chromosomally encoded inducible AmpC  $\beta$ -lactamase. *J Antimicrob Chemother* 2018;73(6):1530–6.
- LIU XQ, LIU YR. Detection and genotype analysis of AmpC  $\beta$ -lactamase in *Klebsiella pneumoniae* from tertiary hospitals. *Exp Ther Med* [Internet] 2016 [cited 2025 Aug 6];12(1):480–4. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4906708/>
  - Inamdar DP, B A. Phenotypic methods for detection of Amp C  $\beta$  lactamases in Gram negative clinical isolates of a tertiary care hospital. *Indian J Microbiol Res* [Internet] 2025 [cited 2025 Sep 22];7(2):125–9. Available from: <https://ijmronline.org/archive/volume/7/issue/2/article/18973>
  - Ashok AK, Jaryal SC, Thakur K, Sood A, Gupta PK, Thakur S. Detection of Inducible and Non-inducible (constitutive) AmpC  $\beta$ -lactamase-producing Gram-Negative Bacteria among Family Enterobacteriaceae by Two Phenotypic Methods-Disk Antagonism Test (DAT) and AmpC disk Test at a Tertiary Care Hospital, Himachal Pradesh, India. *Int J Curr Microbiol Appl Sci* [Internet] 2016 [cited 2025 Sep 22];5(4):133–9. Available from: <http://www.ijcmas.com/abstractview.php?ID=311&vol=5-4-2016&SNo=18>
  - Rosco DiaTabs.pdf [Internet]. [cited 2025 Aug 6];Available from: <https://www.keyscientific.com/files/Other%20Manufacturers/Rosco/DiaTabs/Rosco%20DiaTabs.pdf>
  - Peter-Getzlaff S, Polsfuss S, Poledica M, Hombach M, Giger J, Böttger EC, et al. Detection of AmpC Beta-Lactamase in *Escherichia coli*: Comparison of Three Phenotypic Confirmation Assays and Genetic Analysis. *J Clin Microbiol* [Internet] 2011 [cited 2025 Aug 6];49(8):2924–32. Available from: <https://journals.asm.org/doi/10.1128/jcm.00091-11>
  - Roberts T, Ling CL, Watthanaworawit W, Cheav C, Sengduangphachanh A, Silisouk J, et al. AmpC  $\beta$ -lactamases detected in Southeast Asian *Escherichia coli* and *Klebsiella pneumoniae*. *JAC-Antimicrob Resist* [Internet] 2024 [cited 2025 Aug 6];6(6):dlae195. Available from: <https://doi.org/10.1093/jacamr/dlae195>
  - Cugati S, Lyra PR. Detection of Amp-C Beta Lactamase Enzyme Production among Enterobacteriaceae and Comparison of Different Inducer Substrate Combinations for Detection of Inducible Amp-C. *Int J Curr Microbiol Appl Sci* [Internet] 2019 [cited 2025 Aug 6];8(4):848–54. Available from: <https://www.ijcmas.com/www.ijcmas.com/abstractview.php?ID=12582&vol=8-4-2019&SNo=95>
  - Khari FIM, Karunakaran R, Rosli R, Tay ST. Genotypic and Phenotypic Detection of AmpC  $\beta$ -lactamases in *Enterobacter* spp. Isolated from a Teaching Hospital in Malaysia. *PLOS ONE* [Internet] 2016 [cited 2025 Sep 22];11(3):e0150643. Available from: <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0150643>
  - Ruppé E, Bidet P, Verdet C, Arlet G, Bingen E. First Detection of the Ambler Class C 1 AmpC  $\beta$ -Lactamase in *Citrobacter freundii* by a New, Simple Double-Disk Synergy Test. *J Clin Microbiol* [Internet] 2006 [cited 2025 Sep 22];44(11):4204–7. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC1698308/>
  - El-Hady SA, Adel LA. Occurrence and detection of AmpC  $\beta$ -lactamases among *Enterobacteriaceae* isolates from patients at Ain Shams University Hospital. *Egypt J Med Hum Genet* [Internet] 2015 [cited 2025 Sep 22];16(3):239–44. Available from: <https://www.sciencedirect.com/science/article/pii/S1110863015000154>
  - Joji RM, Al-Mahameed AE, Jishi TA, Fatani DI, Saeed NK, Jaradat A, et al. Molecular detection of plasmid-derived AmpC  $\beta$ -lactamase among clinical strains of Enterobacteriaceae in Bahrain. *Ann Thorac Med* [Internet] 2021 [cited 2025 Sep 22];16(3):287–93. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC8388573/>
  - Polsfuss S, Bloemberg GV, Giger J, Meyer V, Böttger EC, Hombach M. Practical Approach for Reliable Detection of AmpC Beta-Lactamase-Producing Enterobacteriaceae. *J Clin Microbiol* [Internet] 2011 [cited 2025 Sep

**Phenotypic Detection Of Inducible Ampc Beta-Lactamase Producing Gram Negative Bacilli From Tertiary Care Center**

- 22];49(8):2798–803. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC3147735/>
18. Tan TY, Ng LSY, He J, Koh TH, Hsu LY. Evaluation of screening methods to detect plasmid-mediated AmpC in *Escherichia coli*, *Klebsiella pneumoniae*, and *Proteus mirabilis*. *Antimicrob Agents Chemother* 2009;53(1):146–9.