Medico-economic contribution of multiplex PCR to the diagnosis of meningitis

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Abstract

Meningitis is a serious infection that affects the central nervous system with an incidence of 10,76 cases per 100 000 inhabitants in Algeria**.** The constraints encountered when using conventional diagnostic methods (CDMs) for meningitis have led to developing new diagnostic methods, including multiplex PCR (MPCR). The aim was to evaluate the medico-economic contribution of MPCR compared with CDMs.

A Medico-economic modelling was established over five-years, showing comparative costs between MPCR and CDMs in three scenarios considered when simplex-PCR detected the pathogenic germ: from the 1st test (best case), 4th test (base case), 7th test (worst case) knowing that MPCR can detect six bacteria, seven viruses and one fungus simultaneously. This model is based on results obtained from a hospital laboratory that has been extrapolated to the Algerian population. The data were based on the public and private sectors. After describing the conventional and the new MPCR diagnostic methods, we calculated the costs of a bacteriological examination of cerebrospinal fluid, simplex-PCR and MPCR tests.

359 cases were examined in the hospital laboratory. When comparing conventional diagnostic and MPCR methods, MPCR was more expensive than CDMs in best case. However, in base and worst cases, MPCR were less expensive. The estimated population with meningitis is 4927 people in the first year. A minor increase in the cumulative incremental budget has been observed in the first scenario. However, in 2nd and 3rd scenarios, MPCR have generated significant savings of more than 1,417,366$ and 3,242,796$ respectively over the five years

The comparison between CDMs and MPCR highlights the advantages of this one despite its initial cost. In addition, MPCR reduces the time taken to make a diagnosis, decreasing duration and hospitalization-cost and leading to the appropriate use of antibiotics. This enables early therapeutic adaptation, which influences the patient journey and avoids antibiotic resistance.

Introduction

Meningitis is a serious infection that affects the nervous system. It is caused by bacteria, viruses or fungi that can be life-threatening, especially in infants, children and the elderly [1], and represent a worrying public health problem. In Algeria, the reported incidence rate for 2017 was 10.76 cases per 100,000 inhabitants with a mortality rate of up to 20% [2].

Conventional methods for diagnosing meningitis, based on bacterial culture and simplex PCR are slow and labor-intensive and may lead to delays in appropriate patient management, increasing the risk of neurological sequelae. additionally, these methods can be costly, and often require specialized equipment and trained personnel for diagnosing viral meningitis. These challenges have spurred the development of new diagnostic methods.

Ensuring rapid and accurate diagnosis of meningitis is crucial for effective medical management and to avoid complications.

The aim was to assess the medico-economic contribution of multiplex PCR compared with conventional microbiological diagnostic methods

Methods

This is a medico-economic study of the costs of different methods of diagnosing meningitis, Cerebrospinal fluid (CSF) samples are tested for bacteria using the conventional method (bacterial culture) and for viruses using conventional PCR.

We collected data from public health establishments (Bacteriology-Virology department and central pharmacy of the ISSAD HASSANI hospital) as well as from the private sector.

The costs assessed are the direct costs relating to each of the two methods (conventional - multiplex PCR), taking into account consumables, reagents, instrumentation and equipment used, and the time required to perform each method has also been estimated. The Indirect costs in the public sector were not considered due to lack of data, whereas costs obtained from the private sector include both direct and indirect costs.

we have carried out simulations on an excel file based on a comparison of the costs (direct and indirect) of examinations realized by multiplex PCR method with those incurred by conventional methods over a period of up to 5 years, taking into account demographic trends and the incidence of meningitis, with the aim of assessing the impact of using this method on a national scale. The calculation formula is as follows:

Total Algerian population (45M) * demographic change (1.6) * incidence (10.76/100,000)

Results

During the period from April 2022 to April 2023, a total of 359 cases were examined at the mother and child laboratory of ISSAD HASSANI Hospital. Viral meningitis accounted for 54% compared with 46% of bacterial meningitis, which is in line with the literature [3].

In our comparison with multiplex PCR, we considered various scenarios,including the conventional method of bacterial identification and the conventional method of viral identification This was done in cases where simplex PCR detected the pathogenic germ from the 1st test (case N°1: minimal),4th test (case N°2: average), 7th test (case N°3: maximal).

	Costs (USD)	time to obtain a result (h)
New multiplex PCR method	190,5 $	1
Conventional methods Scenario 1	80,86 $	80
Conventional methods Scenario 2	225,34 $	104
Conventional methods Scenario 3	367,37$	128

Fig 1: Cost and time comparison between the new and the conventional methods

- Cost comparison between conventional methods and multiplex PCR

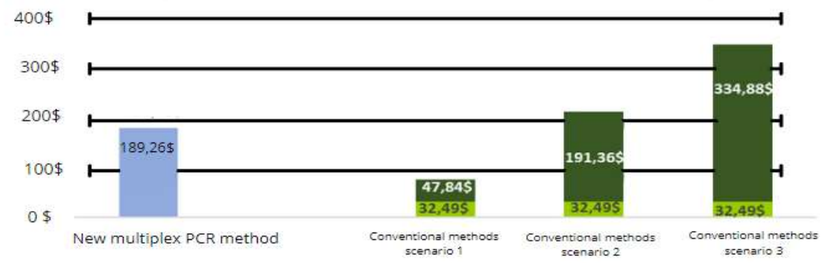

Fig.2: Cost comparison between conventional methods and multiplex PCR

This comparison (fig.2) shows that the cost of multiplex PCR is higher than in scenario 1, whereas the cost of conventional methods is higher in scenarios 2 and 3.

- Comparison in terms of time between conventional methods and multiplex PCR (fig.3)

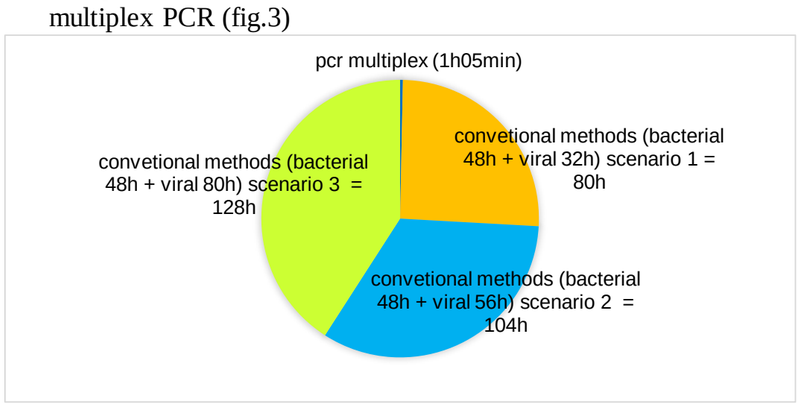

Fig.3: time comparison between Multiplex PCR and conventional methods

- In terms of time, for bacterial identification, multiplex PCR offers the advantage of saving 48 hours in obtaining a result. For viral identification, multiplex PCR offers considerable time savings of 31h for the 1st scenario, 55h for the 2nd scenario and 79h for the 3rd one.
- Medico-economic modelling :

The estimated population with meningitis is 4927 people in the first year, comparative simulations over 5 years between the conventional method and multiplex PCR in Algeria.

The simulated costs in the different scenarios of the use of the new diagnostic method (multiplex PCR) for a period of 5 years are presented as follows (fig.4)

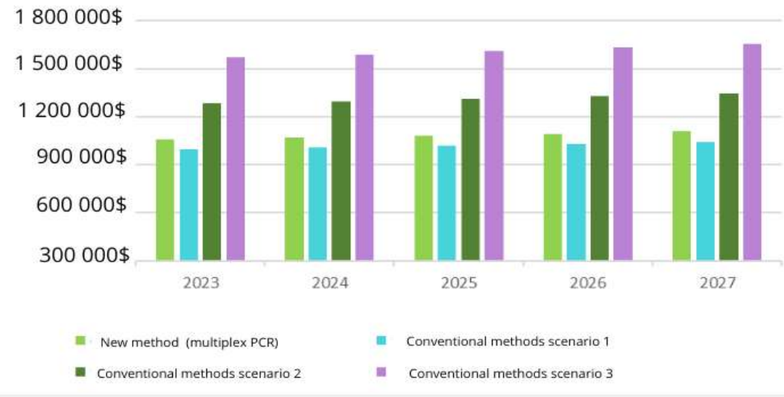

Fig.4: comparative simulations between the conventional method and multiplex PCR in Algeria over 5 years

Discussion

The study revealed that there is no cost advantage for multiplex PCR compared with scenario 1; however, when compared with scenarios 2 and 3, it offers savings of 2,10$ and 145,59$ per test respectively. These simulations over 5 years show that in the first scenario, the costs of the two methods converge without generating any savings. However, in scenarios 2 and 3, the savings achieved amount to 1,417,366$ and 3,242,796$ respectively from 2023 onwards.

The comparison between conventional diagnostic methods and the new multiplex PCR method, which at first sight appears costly, highlights the reduction in diagnosis time and consequently the length and cost of hospitalization as well as the consumption of antibiotics. in addition, it enables the detection of germs killed by antibiotic therapy, It therefore enables early therapeutic adaptation [4] that has a considerable influence on the course of care and indirectly on antibiotic resistance, which then plays a major role in the patient's vital prognosis.

Viral identification by multiplex PCR allows to avoid false negatives, which leads to an optimization of the positivity rate, thereby reducing the costs associated with the length of hospitalization, such as hospital charges and repeated laboratory analyses. By improving the sensitivity, specificity and speed of diagnosis, these new methods avoid inappropriate and costly treatments, namely the administration of broad-spectrum antibiotics, which in turn reduces the costs associated with side-effects and antibiotic resistance.

Despite the many advantages that multiplex PCR offers in terms of cost and time, it is limited to community-acquired meningitis despite the fact that community-acquired meningitis represents a significant proportion of meningitis cases in Algeria [5].

Conclusion

Both diagnostic methods (conventional and multiplex PCR) are complementary, and it is therefore recommended that an approach based on the patient's clinical context be adopted, enabling both methods to be used rationally for greater reliability in the diagnosis of meningitis.

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