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Use of programmable valve versus fixed pressure valve in the treatment of idiopathic normal pressure hydrocephalus: a systematic review and meta-analysis

Adriano Anzai[1], Armelim Utino[1], Haroldo Katayama[1], Ighor Alexander Zamuner Spir[1], Mary Martins Nery[1], Mauricio Anhesini[1], Oswaldo Silvestrini Tiezzi[1], Patricia RN Spir[1], Pericles Otani[1], Clara Lucato dos Santos[2], Luca Schiliró Tristão[2], Wanderley M. Bernardo[2,3*]

The Guidelines Project, an initiative of the Brazilian Medical Association, aims to combine information from the medical field to standardize how to conduct and assist in the reasoning and decision-making of doctors. The information provided by this project must be critically evaluated by the physician responsible for the conduct that will be adopted, depending on the clinical condition of each patient.
Authorship: Brazilian Medical Association

INTRODUCTION

Idiopathic normal pressure hydrocephalus (iPNH) manifests itself through the clinical triad of gait disorders, dementia, and urinary incontinence, which is associated with radiological images of ventriculomegaly and normal intracranial pressure. The most commonly performed treatment is the placement of a ventriculoperitoneal valve or ventriculoperitoneal shunt when there is a positive response to TAP test 1. Clinical improvement is significant after this procedure, but overdrainage, subdural hematoma, or other complications may occur, making reinterventions necessary. There are numerous types of valves that can be used: fixed pressure ones (slit, membrane, or ball/spring) and second-generation ones, including anti-siphon, gravitational, and adjustable or programmable. Theoretically, programmable or adjustable valves would have advantages over fixed pressure valves. Our aim was to assess whether programmable or adjustable valves are superior to fixed pressure valves.

METHODOLOGY

This systematic review followed the precepts defined by the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA)[1].

Clinical issue

The systematic review began with the elaboration of the following clinical question: Is the treatment of normal pressure hydrocephalus using programmable valves more effective when compared to fixed pressure ones?

PICO

The clinical question was structured from the acronym PICO being:

- P: patients with iPNH
- I: programmable valve
- C: fixed pressure valve
- O: clinical improvement, prognosis, reinterventions, and complications

Search strategy

Searches were performed in Medline (PubMed), Embase, CENTRAL (Cochrane), and LILACS databases with the following terms: (hydrocephalus) AND (ventriculoperitoneal shunt OR programmable valve OR adjustable valve).

Eligibility criteria

- PICO compliant items
- At least one of the outcomes compatible with those evaluated, such as clinical improvement, prognosis, reinterventions, and complications
- Randomized clinical trials (RCTs) to evaluate efficacy
- RCTs and observational studies to assess adverse events and complications
- No period and language restriction

[1]Unimed Presidente Prudente, Medicina Baseada em Evidências Center – Presidente Prudente (SP), Brazil.
[2]Centro Universitário Lusíada, Faculdade de Ciências Médicas de Santos, Center for Evidence-Based Medicine – Santos (SP), Brazil.
[3]Universidade de São Paulo, Guidelines Program of the Brazilian Medical Association – São Paulo (SP), Brazil.
*Corresponding author: wmbernardo@usp.br
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Exclusion criteria

In vitro studies, animal studies, case series or case reports, systematic or narrative reviews, and guidelines.

Data analysis

The following information was extracted: author, year of publication, study design, characteristics and number of patients, intervention, comparison, and outcomes (clinical improvement and complications). Each article was described individually in a qualitative analysis of the evidence. Furthermore, quantitative analysis of the results (meta-analysis) was performed whenever possible. For the meta-analysis, Review Manager (RevMan) Version 5.4[2] was used. Comparisons were demonstrated in risk difference (RD) and 95% confidence interval (95%CI). The inconsistency of effects across interventions was assessed using I^2. The random-effects model was used if I^2>50% and the fixed-effects model was used if I^2≤50%. To access possible publication biases, the *funnel plot* was analyzed for asymmetry. The certainty of the evidence was assessed using the GRADE Pro guideline development tool[3] and rated as high, moderate, low, or very low.

Bias analysis

To assess RCT bias, the following were evaluated: randomization, blinded allocation, double blinding, losses (<20%), intention-to-treat analysis, definition of outcomes, sample size calculation, early discontinuation, and prognostic characteristics. For observational studies, the ROBINS-I platform was used[4].

RESULTS

The search was conducted until December 2022 and retrieved a total of 16,882 articles in the primary databases (Medline: 5,879; Embase: 10,507; LILACS: 338 Lilacs; Cochrane: 158). After removing duplicates, they totaled 8,728 articles. All of them had their titles checked, and 223 abstracts were reviewed for inclusion. The reading of 40 complete texts was carried out to verify compatibility with the defined eligibility criteria. Finally, four comparative studies were included[5-8] (Table 1) (Figure 1). Bias analysis showed that the articles have low-to-moderate risk of bias (Table 2 and Figure 2).

Efficacy

Farahmand et al.[5], in a RCT, reported the clinical evolution of their patients. The measure used was the *total standard deviation score*, which involved the Stroop test, the Grooved Pegboard test, walking duration, and number of steps taken. After 6 months, both groups had a statistically different evolution compared to the preoperative period (I: -0.23±1.10 vs. 0.46±0.27; C: 0.09±0.67 vs. 0.52±0.30; p<0.05). However, between groups, there was no statistical difference in any of the assessments until the end of the study, 6 months after valve placement (p>0.05) (Figure 3). In the evaluation of each parameter separately, a significant difference was also found in relation to the baseline in all tests (p<0.05) but without difference between groups.

Complications: randomized clinical trials and observational studies have evaluated complication rates

Complications analyzed through randomized clinical trials

Sæhle et al.[6], an article derived from the same RCT by Farahmand et al.[5], reported complications after valve placement. Notably, six (17.7%) patients with programmable valves had shunt-related complications, four of which had subdural hematomas.

Table 1. Characteristics – comparative studies.

Author	Year	Study design	Groups		Outcomes	Follow-up
			I	C		
Rinaldo et al.[8]	2019	Cohort	Programmable valve (n=98)	Fixed-setting valve (n=250)	Complications	–
Serarslan et al.[7]	2017	Cohort	Programmable valve (n=30) Mean age: 62 years	Fixed-setting valve (n=80) Mean age: 61 years	Complications	72 months
Farahmand et al.[5]	2016	RCT	Programmable valve (n=34) 20 cm H_20 – 4 cm	Fixed-setting valve (n=34) 12 cm H_20	Stroop test, Grooved Pegboard test, Walk time, Walk steps	6 months
Saehle et al.[6]	2014	RCT	Programmable valve (n=34) 20 cm H_20 – 4 cm	Fixed-setting valve (n=34) 12 cm H_20	Complications	6 months

Furthermore, seven patients had symptoms due to excessive drainage. In patients with a fixed valve, seven (20.6%) patients had complications related to the shunt, with five subdural hematomas. Another four patients had symptoms of excessive drainage. All comparisons had p>0.05. In patients with iPNH who underwent implantation of a programmable valve compared to a fixed pressure valve, there was no difference in complications at the 6-month follow-up (Figure 4). The quality of

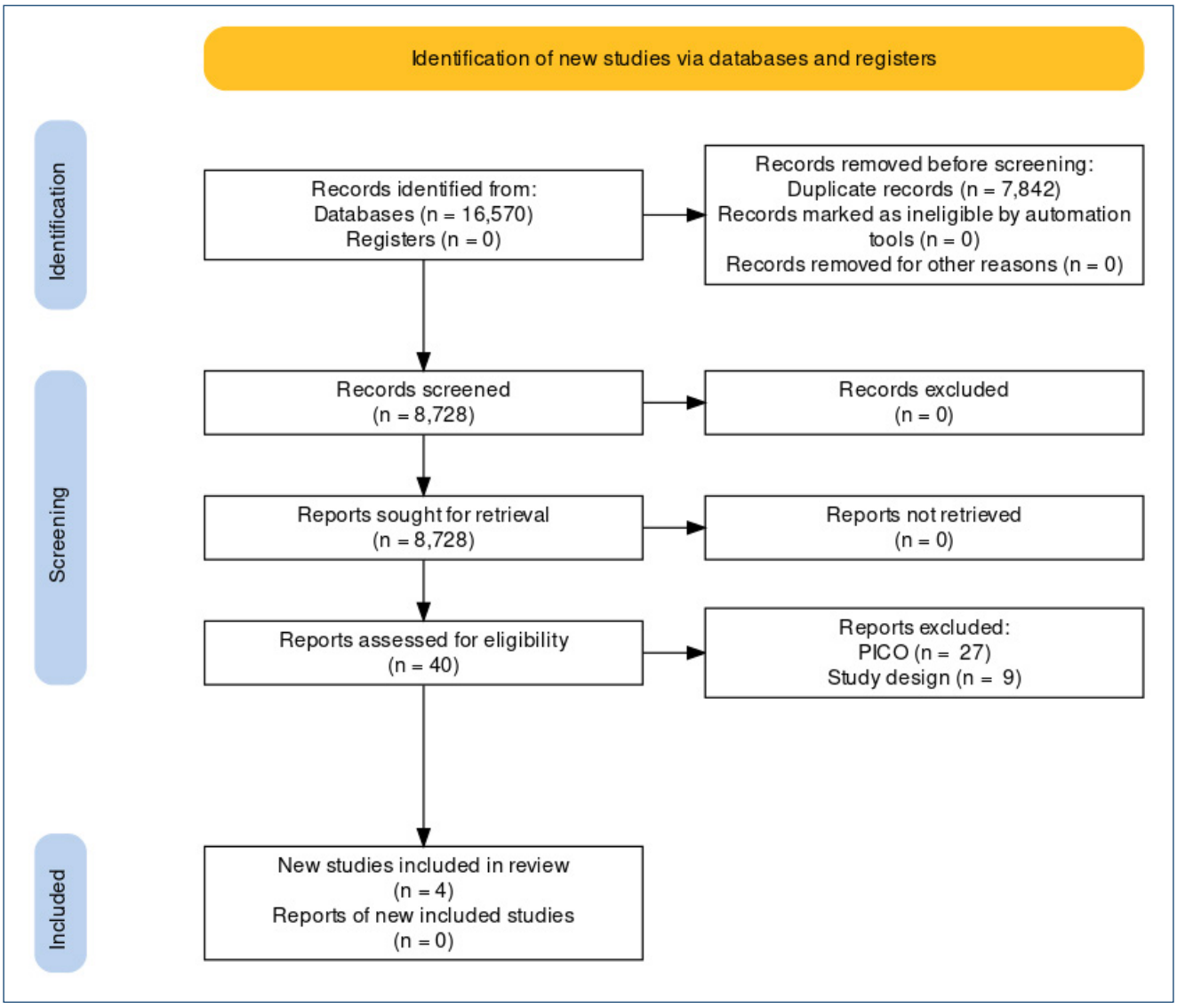

Figure 1. PRISMA flow diagram.

Table 2. Bias – randomized controlled trial.

Studies	Randomization	Allocation	Double blind	Evaluator blind	Losses	Characteristics	Outcomes	ITT analysis	Sample size	Early end
Farahmand et al.[5]										
Saehle et al.[6]										

ABSENCE OF BIAS
ABSENCE OF INFORMATION
PRESENCE OF BIAS

evidence is very low. In patients with iPNH who underwent implantation of a programmable valve compared to a fixed pressure valve, there was no difference in the incidence of overdrainage at the 6-month follow-up (Figure 5). The quality of evidence is very low.

Complications analyzed through cohort studies

Serarslan et al.[7], a cohort, also reported complications in their study. In the group with programmable valves, 26.33% had complications, while in the group with fixed valves, 52.5% had (p=0.02). Subdural effusions occurred in 20% of patients

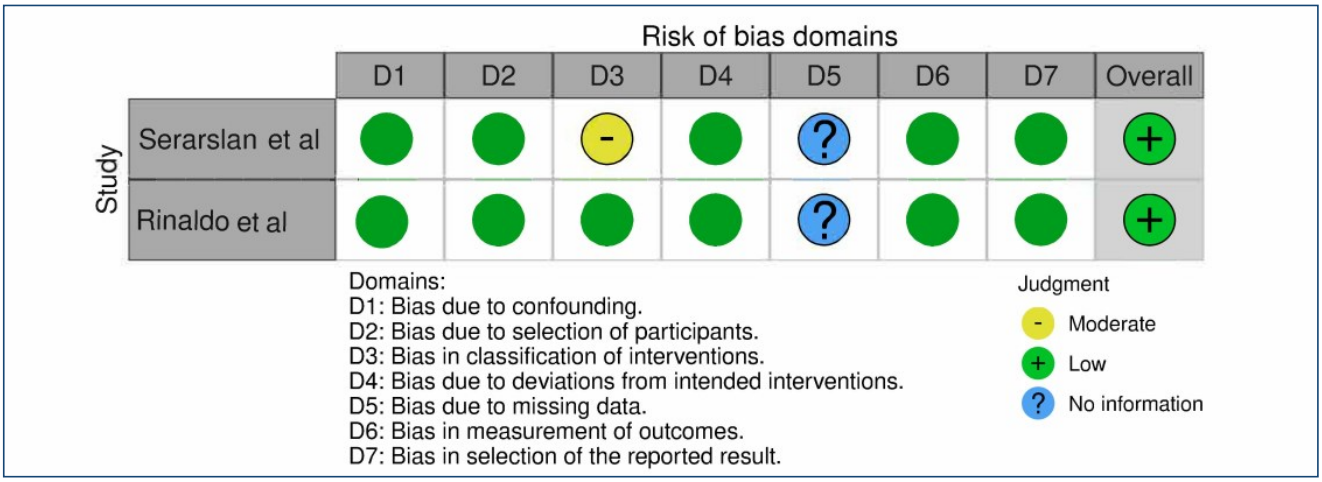

Figure 2. Bias - cohorts (ROBINS-I).

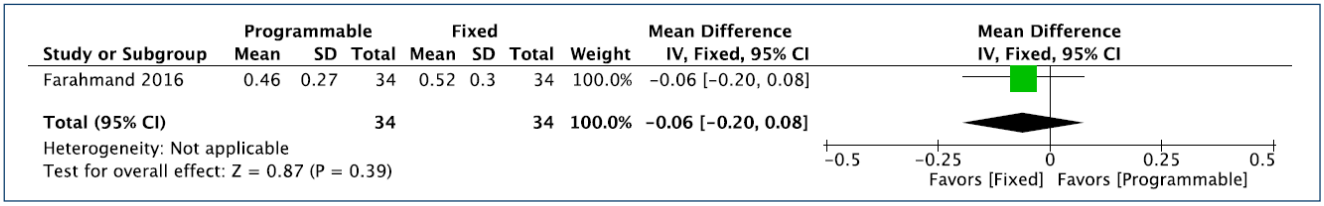

Figure 3. Analysis of clinical evolution (walking test, Stroop test, and Grooved Pegboard test) comparing programmable valve versus valve with fixed pressure.

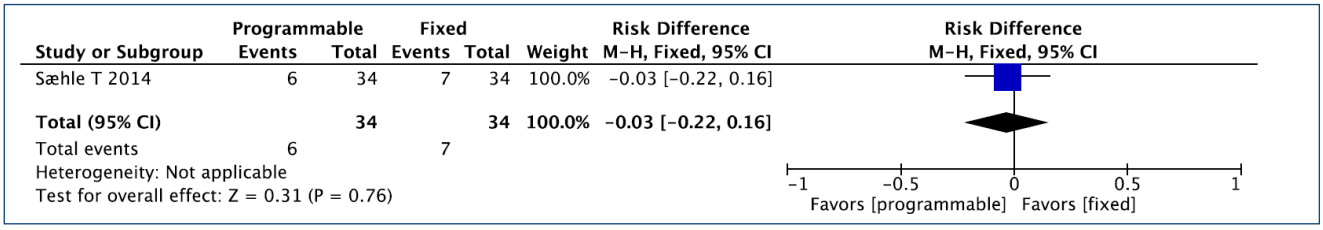

Figure 4. Analysis of complications in comparing programmable valve versus valve with fixed pressure.

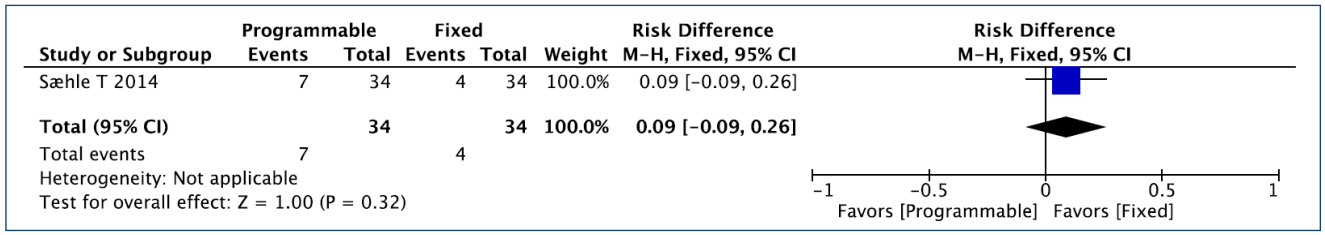

Figure 5. Analysis of the incidence of overdrainage when comparing the programmable valve versus the valve with fixed pressure.

with programmable valves and 22.5% with fixed valves (p=0.78). Nontraumatic subdural hematomas occurred in 11 (13.75%) patients with fixed valves, and of these, 2 died. In the programmable ones, only one patient had this complication (p=0.15).

Rinaldo et al.[8], another cohort, reported that complications occurred in 13.3% of patients with programmable valves and 24.0% of patients with fixed valves (p=0.03). Revision surgery for distal obstruction occurred in 1.0% of those with programmable valves and 6.8% of those with fixed valves (p=0.06), and persistence of symptoms without obstruction in 2.0 and 8.8% (p=0.04), respectively.

Meta-analysis of the complication rate in two observational studies[7,8] revealed that patients with programmable valves had a lower risk of complications than those with fixed valves (RD=-0.16; 95%CI -0.30, -0.02; p=0.03; I^2=51%; random model; certainty of evidence: very low) (Figure 6).

DISCUSSION

Efficacy and complications analyzed through randomized clinical trials

There are no randomized trials directly comparing programmable valves and conventional valves in patients with iPNH. However, comparing these patients with the use of programmable valves with gradual pressure reduction (independent of symptoms) and with fixed pressure, no differences were found in clinical evolution, complications, or overdrainage. The evidence supporting these conclusions is of very low quality.

Complications in observational studies

Several single-arm observational studies have reported complications in patients with programmable valves. Feletti et al.[9], in a cohort of 142 patients, reported 30 cases of symptoms due to poor drainage and 10 due to excessive drainage. In addition, 43 shunt adjustments were performed. Finally, 7 patients had subdural hematoma and 10 had hygroma. Ma et al.[10] reported that the complication rate was 40% (41/102), with the most prevalent being subdural hematoma and hygroma, with 28 cases. They also reported the need for 85 shunt adjustments. Shaw et al.[11] reported 3 subdural hematomas and 3 shunt revisions among 45 patients involved in their study. Oliveira et al.[12] reported 4 subdural hematomas, 1 empyema, 2 malfunctions, and 1 valve exposure in 24 patients involved in their study. Finally, Zemack et al.[13] reported 14 subdural hematomas or hygromas, 2 proximal catheter obstructions, and 138 shunt adjustments in 147 patients involved in their study.

Limitations

This review has some limitations. Only two RCTs that responded to PICO were found. Furthermore, both are part of the same series, only reporting different outcomes in each publication. It is evident that there is a flaw in the literature when comparing fixed and programmable valves in patients with iPNH, limiting the conclusions on the subject. Only these two reported outcomes were related to the effectiveness of the techniques, while the observational ones described only adverse events and complications.

CONCLUSION

In patients with iPNH, no evidence is currently available that allows recommending the use of programmable valves in the treatment of these patients, in comparison, or that leads to the discontinuation of the use of conventional (fixed) valves. The quality of the available evidence is very low.

AUTHORS' CONTRIBUTIONS

AA: Conceptualization, Date curation, Formal Analysis, Validation, Visualization, Writing – original draft, Writing – review & editing. **HK:** Conceptualization, Date curation, Formal Analysis, Validation, Visualization, Writing – original draft, Writing – review & editing. **IAZS:** Conceptualization, Date curation, Formal Analysis, Validation, Visualization,

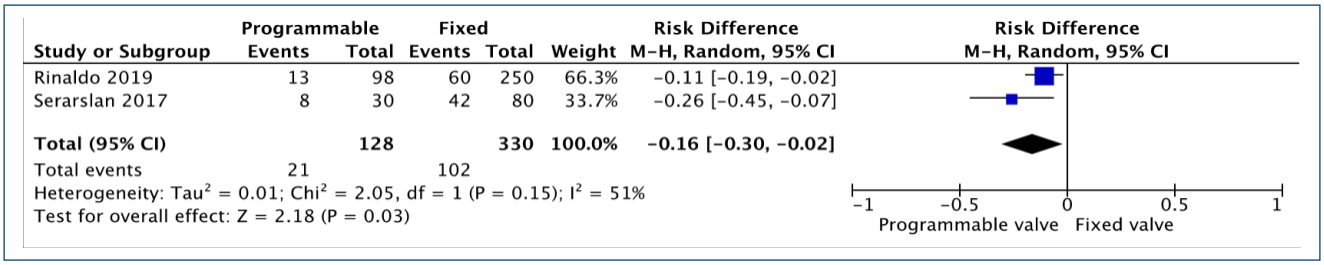

Figure 6. Complications.

Writing – original draft, Writing – review & editing. **MMN:** Conceptualization, Date curation, Formal Analysis, Validation, Visualization, Writing – original draft, Writing – review & editing. **MA:** Conceptualization, Date curation, Formal Analysis, Validation, Visualization, Writing – original draft, Writing – review & editing. **OST:** Conceptualization, Date curation, Formal Analysis, Validation, Visualization, Writing – original draft, Writing – review & editing. **PRNS:** Conceptualization, Date curation, Formal Analysis, Validation, Visualization, Writing – original draft, Writing – review & editing. **PO:** Conceptualization, Date curation, Formal Analysis, Validation, Visualization, Writing – original draft, Writing – review & editing. **CLS:** Formal Analysis, Validation, Visualization, Writing – original draft, Writing – review & editing. **LST:** Formal Analysis, Validation, Visualization, Writing – original draft, Writing – review & editing. **WMB:** Conceptualization, Date curation, Formal Analysis, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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