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**Maternal steroid therapy for fetuses with immune-mediated complete atrioventricular block:  
a systematic review and meta-analysis**

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**Key words:** fetal heart, fetal echocardiography, steroids, ultrasound, heart block, autoimmune

**Key message:** The findings from this systematic review do not suggest a potential positive contribution of antenatal steroid therapy in improving the outcome of fetuses with immune CAVB

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## ABSTRACT

**Introduction:** To explore the effect of maternal fluorinated steroid therapy on fetuses affected by immune-mediated complete atrio-ventricular block (CAVB) in utero.

**Material and Methods:** Pubmed, Embase, Cinahl and ClinicalTrials.gov databases were searched. Only studies reporting the outcome of fetuses with immune CAVB diagnosed on prenatal ultrasound without any cardiac malformations and treated with fluorinated steroids compared to those not treated were included. The primary outcome observed was the regression of CAVB; secondary outcomes were: need for pacemaker insertion overall mortality, defined as the occurrence of either intra-uterine (IUD) or neonatal (NND) death, IUD, NND, termination of pregnancy (TOP). Furthermore, we assessed the occurrence of all outcomes in fetuses with compared to those without hydrops at diagnosis. Meta-analyses of proportions using random effect model and meta-analyses using individual data random-effect logistic regression were used to combine data.

**Results:** Eight studies (162 fetuses) were included. The rate of regression was 3.0% (95% CI 0.2-9.1) in fetuses treated and 4.3% (95% CI 0.4-11.8) in those not treated, with no difference between the two groups (OR: 0.9, 95% CI 0.1-15.1). Pacemaker at birth was required in 71.5% (95% CI 56.0-84.7) of fetuses treated and 57.8% (95% CI 40.3-74.3) of those not treated (OR: 9, 95% CI 0.4-3.4). There was no difference in the overall mortality rate (OR: 0.5, 95% CI 0.9-2.7) between the two groups; in hydropic fetuses, mortality occurred in 76.2% (95% CI 48.0-95.5) of the treated and in 23.8% (95% CI 1.2-62.3) of the untreated group, while in those with hydrops the corresponding figures were 8.9% (95% CI 2.0-20.3) and 12% (95% CI 8.7-42.2) respectively. Improvement or resolution of hydrops during pregnancy occurred in 76.2% (95% CI 48.0-95.5) of cases treated and in 23.3% (95% CI 1.2-62.3) of those non-treated with fluorinated steroids.

**Conclusions:** The findings from this systematic review do not suggest a potential positive contribution of antenatal steroid therapy in improving the outcome of fetuses with immune CAVB.

**Abbreviation:** Atrioventricular block (AVB), structural congenital heart diseases (CHD),

complete AVB (CAVB), confidence interval (CI), odds ratio (OR)

**What's already known about this topic?** CAVB is irreversible, however, some have suggested that administration of fluorinated steroids may be improve the outcome of these fetuses

**What does this study add?**The findings from this systematic review do not suggest a potential positive contribution of antenatal steroid therapy in improving the outcome of fetuses with immune CAVB

JUST ACCEPTED

## **Introduction**

Atrioventricular block (AVB) encompasses a wide spectrum of conditions characterized by a delay or interruption in the transmission of an impulse from the atria to the ventricles due to an anatomical or functional impairment in the conduction system (1). AVB can be associated with structural congenital heart diseases (CHD); however, when isolated, it is usually the results of trans-placental passage of maternal autoantibodies, such as Ro/SSA and La/SSB, with subsequent inflammation and fibrous replacement of the conduction system (2,3)

Immune AVB is a progressive disease characterized by different degrees of abnormal AV conduction. First-degree AVB is characterized by a delayed conduction time of the impulse from the atria to the ventricle, while second-degree refers to a failure to conduct some, but not all, atrial impulses to the ventricles. Finally, third degree or complete (CAVB) atrioventricular block denotes a situation where there is no AV conduction at all, and the atria and ventricles beat independently (1).

CAVB is the most severe type of AVB and is associated with high rate of perinatal mortality and morbidity. Slow ventricular rhythm, hydrops and early gestational age at birth represent the main determinants of perinatal outcome in fetuses affected by CAVB (1-4).

CAVB is irreversible; however, some have suggested that administration of fluorinated steroids may be improve the outcome of these fetuses (5). Furthermore, the actual occurrence of hydrops, mortality and pacing in fetuses affected by CAVB block has not been fully elucidated yet.

The aim of this systematic review was to ascertain the role of maternal steroids therapy in affecting the outcome of fetuses diagnosed with immune CAVB.

## **Material and Methods**

This review was performed according to a protocol designed a priori and recommended for systematic reviews (6). Medline, Embase and ClinicalTrials.gov databases were searched electronically on 24.06.2016 utilizing combinations of the relevant medical subject heading (MeSH) terms, key words, and word variants for “complete” or “third degree” fetal heart block” “autoimmune disease” “echocardiography” “corticosteroids” “and “outcome.” Reference lists of relevant articles and reviews were hand searched for additional reports. Before data extraction, the review was registered with the PROSPERO International Prospective Register of Systematic Reviews (registration No.: CRD42016045713) following the PRISMA guidelines for protocols (PRISMA-P) (7).

Only fetuses with immune-mediated CAVB block and morphologically normal heart diagnosed on prenatal ultrasound and treated with fluorinated steroids compared to those not treated were included. Therapy with steroids included any type of fluorinated corticosteroids used.

Only full text articles were considered eligible for the inclusion; case reports and conference abstracts were excluded to avoid publication bias. Furthermore, only studies published in the last two decades (2017-1997) were considered suitable for the inclusion, as we considered that advances in prenatal imaging techniques, improvements in the diagnosis and management of CAVB make these less relevant. Cases with non-immune AVB, those for which maternal antibody status could not be ascertained and those associated with major CHD were excluded. Finally, studies not providing a clear classification of the anomaly were not considered suitable for the inclusion in the current review.

Two authors (AC, FD) reviewed all abstracts independently. Agreement regarding potential relevance was reached by consensus with a third reviewer (VB); full text copies of those articles were obtained and the same two reviewers independently extracted relevant data regarding study characteristics and pregnancy outcome. Inconsistencies were discussed and consensus was reached or the dispute was resolved by discussion with a third author. If more than one study was published for the same cohort with identical endpoints, the report containing the most comprehensive information on the population was included to avoid overlapping populations. For those articles in which information was not reported but the methodology was such that this information would have been recorded initially, the authors were contacted.

Quality assessment of the included studies was performed using the Newcastle-Ottawa Scale (NOS). According to NOS, each study is judged on three broad perspectives: the selection of the study groups; the comparability of the groups; and the ascertainment outcome of interest. Assessment of the selection of a study includes the evaluation of the representativeness of the exposed cohort, selection of the non-exposed cohort, ascertainment of exposure and the demonstration that outcome of interest was not present at start of study. Assessment of the comparability of the study includes the evaluation of the comparability of cohorts on the basis of the design or analysis. Finally, the ascertainment of the outcome of interest includes the evaluation of the type of the assessment of the outcome of interest, length and adequacy of follow-up. According to NOS a study can be awarded a maximum of one star for each numbered item within the Selection and Outcome categories. A maximum of two stars can be given for Comparability (8).

The primary outcome observed was the regression of the CAVB to either first or second degree AVB in fetuses treated compared to those not treated with fluorinated steroids during pregnancy.

The secondary outcomes were:

- Need for pacemaker
- Overall mortality, defined as the occurrence of either intra-uterine (IUD) or neonatal (NND) death.
- IUD
- NND
- Termination of pregnancy (TOP)

We also aimed to stratify the analysis assessing all the explored outcomes in according to the fetal status at diagnosis (hydrops vs no hydrops) and we evaluated whether steroid therapy was associated with an improvement of hydrops. Furthermore, we planned to ascertain the occurrence of all the explored outcomes at either the first electrocardiographic (ECG) assessment after the birth and at follow-up, defined as the last assessment according to the duration of each study (1).

For the quantification of the incidence of the outcome explored, meta-analyses of proportions using random effect model were used to combine data. Funnel plots displaying the outcome rate from individual studies versus their precision (1/standard error) were carried out with an exploratory aim. Tests for funnel plot asymmetry were not used when the total number of publications included for each outcome was less than ten. In this case, the power of the tests is too low to distinguish chance from real asymmetry (9-12). Between-study heterogeneity was explored using the  $I^2$  statistic, which represents the percentage of between-study variation that is due to heterogeneity rather than chance(12).

Furthermore, we evaluated separately the risk of pacemaker insertion, regression, mortality in fetuses treated compared to those not treated with steroids prenatally. We included observational cohort studies in which: (a) comparisons reported zero events in one groups; (b) comparisons reported zero events in both groups; (c) exposed and unexposed group sizes were unbalanced. In such a case, many of the most commonly used meta-analytical methods - including those using risk difference (which could be used to handle total zero event studies) - can produce biased

estimates when events are rare (14-16). When many studies are also substantially imbalanced, the best performing methods are the Mantel-Haenszel odds ratio without zero-cell continuity corrections, logistic regression and an exact method. Mantel-Haenszel odds ratios cannot be computed in studies reporting zero events in both groups, the exclusion of which may however cause a relevant loss of information and the potential inflation of the magnitude of the pooled exposure effect. Therefore, to keep all studies into the analyses, we performed all meta-analyses using individual data random-effect logistic regression, with single study as the cluster unit (16). The pooled datasets with individual data were reconstructed using published 2X2 tables. When one of the overall pooled arms showed no events, we used exact logistic regression (16). Finally, Wald test was performed in order to explore the power of the test for each given sample size. All analyses were performed using StatsDirect Ltd. StatsDirect statistical software (England: StatsDirect Ltd. 2013) and Stata version 13.1 (Stata Corp., College Station, TX, 2013).

## Results

370 articles were identified, 20 were assessed with respect to their eligibility for inclusion (Supplementary Table 1) and 8 studies included in the systematic review (Table 1, Figure 1). All pregnancies included were positive for SSA/Ro and/or SSB/La antibodies; maternal therapy other than fluorinated steroids was not described in detail in the majority of the included studies.

No randomized controlled trial on steroid therapy versus no such therapy or placebo in fetuses affected by CAVB was found in the medical databases explored, thus only non-randomized studies were included in the present systematic review. These 8 studies included 162 fetuses with a prenatal diagnosis of immune CAVB (85 treated and 67 not treated).

Dexamethasone was the fluorinated steroids used in the vast majority of studies at a preferred dose of 4-8 mg/day, although the dose protocol and the gestational age at administration of the drug was not reported in all the studies included in the review. Type and timing of post-natal assessment was reported only by few of the included studies (Table 1); finally, the type of pacing (permanent vs temporary) adopted in each study was not specified.

Quality assessment of the included studies performed using Newcastle-Ottawa Scale (NOS) for cohort studies is shown in Table 2. Most of the included studies showed an overall good rate with regard to the selection and comparability of the study groups; the main weaknesses of these studies were their retrospective design, small sample size and a large heterogeneity in drug protocol, gestational age at therapy and time at follow-up.

Assessment of the risk for each of the outcomes explored in the present systematic review was problematic. Only a small proportion of the included studies reported a direct comparison between fetuses treated vs those not treated with steroids, thus not representing the entire population of fetuses included in this systematic review (Table 3, Table 4). The very small number of included cases led to a lack of statistical power which precluded a comprehensive assessment of the strength of association between antenatal steroid therapy and each of the outcomes observed in the present systematic review. Therefore, we opted to report the occurrence of outcomes explored in this systematic review as pooled proportions and then as OR (Table 3, Table 4).

### ***Synthesis of results***

#### ***Regression***

Six studies including 49 cases treated and 45 non-treated with fluorinated steroids explored the likelihood of regression to either first or second degree of CAVB. The rate of regression was 3.0% (95% CI 0.2-9.1) in fetuses treated and 4.3% (95% CI 0.4-11.8) in those not treated, with no difference between the two groups (OR: 0.9, 95% CI 0.1-15.1) (Table 4; Figure 2).

#### ***Pacing***

Six studies including 40 fetuses treated and 37 not treated with fluorinated steroids reported the need for pacemaker insertion at birth for immune CAVB. In the group of fetuses treated and in with fluorinated steroids therapy the need for pacemaker was 71.5% (95% CI 56.0-84.7) and 57.8% (95% CI 40.3-74.3) with no difference between the two groups (OR: 1.09, 95% CI 0.4-3.4) (Table 3 and 4; Figure 3).

#### ***Mortality***

The occurrence of either IUD or NND (overall mortality) was 12.7% (95% CI 5.9-21.6) in fetuses treated and 12.0% (95% CI 2.9-25.9) in those non-treated with fluorinated steroids during pregnancy, with no difference between the two groups (OR: 0.5, 95% CI 0.9-2.7) (Table 3 and Table 4).

IUD occurred in 11.5% (95% CI 5.1-20.1) of fetuses treated and in 10.1% (95% CI 2.9-20.8) of those non-treated while the corresponding figures for NND were 3.7% (0.5-9.7) and

5.3%(0.9-13.0) respectively.

Finally, termination of pregnancy was requested in 2.7% (95% CI 0.2-7.9) of treated with fluorinated steroid and 15.0% (95% CI 2.2-36.4) of untreated group.

### ***Fetal status at presentation (hydropic vs non-hydropic fetuses)***

Sub-analysis according to fetal status at presentation was affected by the very small number of included studies (Supplementary Tables 2).

In fetuses presenting with hydrops, pacemaker at birth was needed in all cases (treated and non-treated) included in the present systematic review 100% (95% CI 43.9-100), while in those without hydrops the corresponding figures for treated and non-treated cases were 63.5% (95% CI 45.0-79.8) and 66.2% (95% CI 47.5-82.4) respectively. There was no case of regression of the block in hydropic fetuses while in non-hydropic fetuses the regression occurred in 6.4% (95% CI 0-23.8) in the treated group and 106% (95% CI 0.6-30.4).

In fetuses with hydrops, mortality occurred in 76.2% (95% CI 48.0-95.5) in the treated and 23.8% (95% CI 1.2-62.3) in the untreated group, while the corresponding figures in those without hydrops were 8.9% (95% CI 2.0-20.3) and 12% (95% CI 8.7-42.2) respectively.

Improvement or resolution of hydrops during pregnancy occurred in 76.2% (95% CI 48.0-95.5) of cases treated and in 23.3% (95% CI 1.2-62.3) of those non-treated with fluorinated steroids (Supplementary Table 2).

## Discussion

The findings from this systematic review show that in fetuses affected by immune CAVB the chance of regression is negligible and it is not affected by steroid therapy. The large majority of fetuses with immune CAVB require pacemaker insertion at birth, with no difference between cases treated and non-treated with fluorinated steroids. Mortality occurs in about 12% of fetuses affected by CAVB and it is not influenced by steroids. Finally, fetuses presenting with hydrops are at generally higher risk of adverse outcome compared to those not affected.

This is the first meta-analysis assessing the role of antenatal fluorinated steroids administration in fetuses affected by immune-mediated CAVB. The strengths of this study are its robust methodology for identifying all possible studies for inclusion, assessing data quality and synthesizing all suitable data.

The small number of cases in the included studies, their retrospective non-randomized design, different periods of follow-up, lack of information of post-natal confirmation of the arrhythmia, dissimilarity of the populations (due to various inclusion criteria) and the lack of fixed criteria for when to treat represent the major limitations of this meta-analysis. The assessment of the potential publication bias was also problematic, both because of the outcome nature (rates with the left side limited to the value zero) which limits the reliability of funnel plots, and because of the scarce number of individual studies, which strongly limits the reliability of formal tests. Many of the included studies were non-controlled. The level of evidence for these types of studies is very low.

The very small number of included cases and the lack of statistical power for all the outcomes explored in the present systematic review did not allow to estimate the actual strength of association between antenatal steroid treatment and each of the observed outcomes. Small sample size of previously published studies, lack of stratification according to fetal status at diagnosis, degree of fetal bradycardia, presence of additional co-treatments either before or after birth, differences in drug protocols, gestational age at administration, interval between diagnosis and treatment and length of treatment and follow-up preclude to draw any strong objective evidence to guide management.

A major limitation of the present systematic review was the lack of stratification according to the degree of fetal bradycardia. Sustained fetal bradycardia is associated with a high risk of hydrops, thus limiting the potential effect of steroids treatment. Lack of stratification of the analysis

according to the interval between diagnosis and treatment is another major limitation of the present systematic review. Immune AVB is characterized by a progressive impairment of cardiac function and it is entirely possible that cases in which treatment is started immediately after diagnosis may experience a better outcome compared to those in which treatment is delayed. In fact, when fetal immune heart block is detected at earlier stages, i.e. second degree AVB, maternal steroid therapy has been associated with some benefit in regression or resolution of the AVB, and lower need for pacemaker after birth (18). Furthermore, although we have stratified the analysis according to the presence of hydrops, the very small number of included cases and the even smaller number of events did not allow us to perform any meaningful data synthesis to assess the risk of the different outcomes in fetuses with compared to those without hydrops. The presence of other co-treatments was another relevant issue. Often studies dealing with CAVB include fetuses receiving multiple treatments, such as sympathomimetic, azathioprine, hydroxychloroquine and immunoglobulin. Although cases receiving only multiple treatments were excluded, it might be entirely possible that cases including other treatments might have not been mentioned in some of the included studies, thus potentially biasing the figures reported. In view of these limitations, the figures reported in this systematic review should be interpreted with caution and might not reflect the actual strength of association between antenatal steroid therapy and each of the outcomes observed. Finally, this review was limited by the study design. Meta-analyses of observational studies are subject of bias (19-22).

Despite this, the present review represents the best published estimate of the effect of maternal steroid therapy for immune CAVB which can be used to guide clinical counseling and management. This is important as counselling for parents based on small studies that are subject to publication bias may be inadequate.

Advances in prenatal echocardiography have led to an increase in the diagnosis of AVB. CAVB is the most severe type of AVB and is associated with high rate of perinatal mortality and morbidity. Prenatal diagnosis of CAVB in utero relies on the precise assessment of the heart rhythm and the relationship between atrial and ventricular depolarization and it is usually accomplished by M-Mode or pulsed wave Doppler echocardiography. CAVB is characterized by a slow ventricular rhythm (usually <60 bpm) in association with AV dissociation and the atria and ventricles beat independently (1).

Risk factors for adverse outcome in fetuses affected by CAVB are fetal hydrops, endocardial fibroelastosis, premature delivery and ventricular rate <55 bpm.

In the present systematic review, we found that about 30% of fetuses with a prenatal diagnosis of CAVB present with hydrops. Fetuses affected by hydrops are known to be at higher risk of perinatal mortality and morbidity compared to those not affected; furthermore, the presence of hydrops can affect trans-placental passage of steroids, thus limiting their bioavailability. In the present systematic review, there was no difference in most of the observed outcomes between hydropic fetuses treated and not treated with fluorinated steroids. However, mortality occurred in 16.7% (95% CI 3.0-56.4) of cases presenting with and in 6.9% (95% CI 0.4-20.2) of those without hydrops, irrespective of steroids administration. These findings concur with those from post-natal studies, which report high rates of mortality (either IUD or NND) in hydropic fetuses. Unfortunately, in view of the very small number of included cases, we could not elucidate whether steroid treatment improved survival rate in those cases presenting with hydrops.

In the present systematic review, we found that improvement or resolution of hydrops during pregnancy occurred in 76.2% (95% CI 48.0-95.5) of cases treated and in 23.8% (95% CI 1.2-62.2) of those non-treated with fluorinated steroids (Supplementary Table 2). These figures should be interpreted with caution; the pathophysiology of hydrops in fetuses affected by immune CAVB is related to a maladaptation of fetal heart to sustained bradycardia which leads to ventricular dilatation, hypertrophy and subsequent reduction of the shortening fraction. Fluorinated steroids do not have any relevant direct effect on ventricular rate; therefore, it might be entirely possible that the high rate of resolution of the hydrops was related to the smaller number of cases of fetuses not treated included in this review or to the presence of additional treatments. Beta-mimetics have been anecdotally reported to increase ventricular rate and improve the outcome of fetuses affected by CAVB (1), although the presence of other co-treatments in these cases makes difficult to ascertain their actual role in the management of this condition.

In conclusion, the findings from this systematic review do not suggest a potential positive contribution of antenatal steroid therapy in improving the outcome of fetuses with immune CAVB. However, in view of all mentioned limitations, it was not possible to completely rule out any potential beneficial effect of steroids therapy on the outcome of fetuses affected by immune CAVB and further evidence is needed before discouraging steroid administration in this anomaly. Prenatal counselling of fetuses affected by immune CAVB should stress the high risk of occurrence of hydrops and mortality in these fetuses, underlining the very low chance of regression and the need of pacemaker insertion immediately after birth in the majority of affected

cases.

Large prospective and adequately powered randomized trials, sharing a common protocol of antenatal management, are urgently needed in order to elucidate the role of maternal fluorinated steroid therapy in modifying the natural history of CAVB in utero.

JUST ACCEPTED

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**Table 2.** Quality assessment of the included studies according to Newcastle-Ottawa Scale (NOS) a study can be awarded a maximum of one star for each numbered item within the Selection and Outcome categories. A maximum of two stars can be given for Comparability.

<b>Author</b>	<b>Year</b>	<b>Selection</b>	<b>Comparability</b>	<b>Outcome</b>
<b>Doti</b>	2016	<input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
<b>Tunks</b>	2013	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
<b>Fesslova</b>	2009	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Friedman</b>	2009	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
<b>Berg</b>	2005	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
<b>jaeggy</b>	2004	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
<b>Saleeb</b>	1999	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Shinohara</b>	1999	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

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**Table 3.** Pooled proportions for the different outcomes observed in this systematic review

<b>Outcome</b>	<b>Studies</b>	<b>Fetuses</b>	<b>I<sup>2</sup></b>	<b>Pooled % (95% CI)</b>	<b>Studies</b>	<b>Fetuses</b>	<b>I<sup>2</sup></b>	<b>Pooled % (95% CI)</b>
	<b><i>Fetuses treated</i></b>				<b><i>Fetuses not treated</i></b>			
<b>Overall regression</b>	6	1/49	0	3.04 (0.2-9.1)	5	1/45	0	4.31 (0.4-11.8)
<b>Need for pacemaker</b>	6	29/40	8.8	71.49 (56.0-84.7)	5	22/37	18.1	57.77 (40.3-74.3)
<b>Mortality (overall)</b>	7	7/64	0	12.66 (5.9-21.6)	6	8/60	52.5	11.97 (2.9-25.9)
<b>IUD</b>	7	6/64	0	11.51 (5.1-20.1)	6	6/60	32	10.07 (2.9-20.8)
<b>NND</b>	6	1/61	0	3.71 (0.5-9.7)	5	2/49	0	5.29 (0.9-13.0)
<b>TOP</b>	7	1/64	0	2.71 (0.2-7.9)	6	10/60	74.7	14.95 (2.2-36.1)

*CI, confidence interval; IUD, intrauterine death; NND, neonatal death ; TOP, termination of pregnancy*

**Table 4.** Pooled odd ratios for the need for pacemaker insertion, regression of the block and mortality in fetuses treated compared to those not treated with fluorinated steroids

<b>Outcome</b>	<b>Studies</b>	<b>Fetuses</b>	<b>I<sup>2</sup> (%)</b>	<b>Pooled OR (95% CI)</b>
<b>Overall regression</b>	4	1/45 vs 1/45	-	0.92 (0.1-15.1)
<b>Need for pacemaker</b>	5	26/36 vs 22/37	0	1.09 (0.4-3.4)
<b>Overall mortality</b>	6	7/60 vs 8/60	13.4	0.49 (0.9-2.7)

*CI, confidence interval; OR, odds ratio*

**Supplementary Table 1.** Excluded studies and reason for the exclusion.

<b>Author</b>	<b>year</b>	<b>Title</b>	<b>Reason for the exclusion</b>
Izmirly	2016	Assessment of fluorinated steroids to avert progression and mortality in anti-SSA/Ro-associated cardiac injury limited to the fetal conduction system	Although the authors reported the overall number of treated and untreated fetuses affected by III degree AVB, it was not possible to extrapolate the occurrence of the explored outcome in each group
Eroren	2016	Short Long term outcome of children with congenital complete heart block diagnosed in utero or as a new born	It was not possible to extrapolate data for cases with immune CAVB
Ho	2015	Isolated Complete Heart Block in the Fetus	It was not possible to extrapolate the data regarding the occurrence of the explored outcome in fetuses with immune III degree AVB
Izmirly	2011	Maternal and Fetal Factors Associated With Mortality and Morbidity in a Multi-Racial/Ethnic Registry of Anti-SSA/Ro-Associated Cardiac Neonatal Lupus	It was not possible to extrapolate the data for any of the outcomes explored in this systematic review in treated vs non treated fetuses affected by immune III degree AVB
Eliasson	2010	Isolated Atrioventricular Block in the Fetus, A Retrospective, Multinational, Multicenter Study of	It was not possible to extrapolate the data regarding the occurrence of the explored outcome in fetuses with immune III

		175 Patients	degree AVB
Makino	2007	Effect of steroid administration and plasmapheresis to prevent fetal congenital heart block in patients with systemic lupus erythematosus and/or Sjogren's syndrome	Only 1 AVB case ( of unknown type) was included in this series
Breur	2005	Transient non autoimmune fetal heart block	No maternal antibody in maternal sera
Julkunen	2004	Autoimmune response in mothers of children with congenital and postnatally diagnosed isolated heart block: a population based study	Study about autoimmune response in mothers of children with AVB; no data for the outcomes explored in this systematic review could be extrapolated from this study
Costedoat-Chalumeau	2003	Questions about dexamethasone use for the prevention of anti SSA related congenital heart block	No case affected by AVB was included in this series.
Jaeggy	2002	Outcome of Children With Fetal, Neonatal or Childhood Diagnosis of Isolated Congenital Atrioventricular Block	It was not possible to extrapolate any data on fetuses with immune III degree AVB
Eroren	2001	Congenital Complete Heart Block in the Fetus: Hemodynamic Features, Antenatal Treatment, and Outcome in Six Cases	Less than three cases of CAVB treated or not treated with fluorinated steroids were included in this series. The other included cases had other treatments
Buyon	1998	Autoimmune associated congenital heart block: demographics, mortality. Morbidity and recurrence rate obtained from a National neonatal lupus registry	This study is likely to share cases with that of Friedman et al. which was considered as the most representative form this research group

**Supplementary Table 2.** Pooled proportions for the different outcomes observed in this systematic review in fetuses presenting with and without hydrops

Outcome	Studies	Fetuses	I <sup>2</sup>	Pooled % (95% CI)	Studies	Fetuses	I <sup>2</sup>	Pooled % (95% CI)
	<i>Fetuses treated</i>				<i>Fetuses not treated</i>			
	<i>Fetuses with hydrops</i>							
Overall regression	2	0/10	0	0 (0-23.2)	1	0/3	-	0 (0-56.2)
Need for pacemaker	2	3/3	-	100 (43.9-100)	1	3/3	-	100 (43.9-100)
Overall mortality	1	0/3	-	0 (0-56.2)	3	1/7	0	18.96 (1.3-50.1)
TOP	1	0/3	-	0 (0-56.2)	3	4/7	75.8	62.49 (4.9-99.9)
Improvement of hydrops	2	8/10	0	76.2 (48.0-95.5)	2	1/5	0	23.83 (1.2-62.3)
	<i>Fetuses without hydrops</i>							
Overall regression	3	1/23	28.5	6.43 (0-23.8)	2	1/14	0	10.56 (0.6-30.4)
Need for pacemaker	4	22/34	15.4	63.46 (45.0-79.8)	3	17/25	0	66.20 (47.5-82.6)
Overall mortality	4	2/34	0	8.97 (1.97-20.3)	3	4/27	70.6	11.97 (8.7-42.2)
TOP	4	0/34	0	0 (0-10)	3	2/27	13.8	8.28 (0.8-22.4)
Occurrence of hydrops	4	0/34	0	0 (0-10)	3	0/25	0	0 (0-12)

*CI, confidence interval; TOP, termination of pregnancy*

### Figure legend

**Figure 1.** Systematic review flowchart.

**Figure 2.** Pooled proportions showing the rate of regression and need for pacemaker in foetuses treated and in those not treated with steroid.

**Figure 3.** Odd ratio for the need of pacemaker in foetuses treated compared to those not treated

with steroids.

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