|  |  |
| --- | --- |
| Question | |
| **Should T-piece resuscitator vs. Self-inflating bag be used for administering PPV at birth?** | |
| **Population:** | Neonates needing positive pressure ventilation (PPV) at birth |
| **Intervention:** | T-piece resuscitator |
| **Comparison:** | Self-inflating bag |
| **Main outcomes:** | In-hospital mortality; Intraventricular hemorrhage (all grades); Intraventricular hemorrhage (grade III-IV); Air leak; Bronchopulmonary dysplasia; Duration of positive pressure ventilation (PPV) in the delivery room (DR); Intubation in DR; cardiopulmonary resuscitation (CPR) or medications in DR; Admission to a neonatal intensive care unit (NICU); Length of hospitalisation |
| **Setting:** | Delivery room |
| **Perspective:** |  |
| **Background:** | It is established that PPV is the most important intervention during neonatal resuscitation and the equipment for providing PPV has been extensively assessed in bench and animal studies. Three device types are commonly used for providing respiratory support, namely the flow-inflating anaesthetic bag, the self-inflating bag (SIB) and T-piece resuscitator (TPR) system. While appropriate treatment with suitable devices can be life-saving, inappropriate use or inadequate equipment can have detrimental effects.  Identification of the most effective device for administering PPV in newborns needing resuscitation at birth is a priority for healthcare providers involved in the care of neonates. |
| **Conflict of interests:** | None. |

# Assessment

|  |  |  |
| --- | --- | --- |
| Problem Is the problem a priority? | | |
| Judgement | Research evidence | Additional considerations |
| ○ No ○ Probably no ○ Probably yes ● Yes ○ Varies ○ Don't know | About 3 to 5% of all newborns (~ 6 million worldwide) receive positive pressure ventilation (PPV) at birth. {Wyckoff 2020 S185} Identifying the most appropriate device for administering PPV is a priority because aerating the newborn’s lungs is the single most important and effective step in neonatal resuscitation. It is important to determine which device most effectively aerates the newborn’s lungs while avoiding lung injury with potential short-term (e.g.,pneumothorax, intraventricular hemorrhage(IVH)) and long-term (e.g., bronchopulmonary dysplasia(BPD)) consequences. |  |
| Desirable Effects How substantial are the desirable anticipated effects? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Trivial ○ Small ● Moderate ○ Large ○ Varies ○ Don't know | Although the intervention did not impact in-hospital mortality and effects on IVH are uncertain, our findings suggest benefit of the TPR over the SIB for decreasing the duration of PPV in the delivery room (19.8 seconds shorter) and reducing the proportion with BPD (32 fewer infants with BPD per 1000 infants). Interventions performed in the delivery room may contribute to the development of BPD. Reducing BPD is one of the most important goals in the care of preterm infants. | A large observational study {Guinsburg 2018 F49} showed that critical outcomes, including in-hospital mortality (NNT 8), IVH -all grades (NNT 8), and IVH grade III-IV (NNT 24) were significantly reduced in the group receiving PPV with a TPR compared to the group receiving PPV with an SIB. |
| Undesirable Effects How substantial are the undesirable anticipated effects? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Large ○ Moderate ○ Small ○ Trivial ○ Varies ● Don't know | For the critical outcome of severe IVH (grade III-IV), unpublished data provided by the author of one small RCT {Thakur 2015 21} and by the author of a cluster randomised clinical trial {Szyld 2014 165} suggested possible harm with the use of a TPR compared with SIB. However, the lack of adjustment for treatment center and the risk of ascertainment bias result in extremely low certainty in these results. Therefore, the data were not included.  It is important to note that the direction of effect for severe IVH from these two randomised trials differs from the large observational study.{Guinsburg 2018 F49} The observational study demonstrated that receiving PPV with a TPR was associated with a decreased risk of IVH (all grades, NNT 8) and severe IVH (grade III-IV, NNT 24). | Although there are findings from 2 randomised trials, the evidence available from them is of extremely low certainty. Thus, the potential role of the device used for ventilation on the critical outcome of severe IVH (grade III-IV) requires further research. |
| Certainty of evidence What is the overall certainty of the evidence of effects? | | |
| Judgement | Research evidence | Additional considerations |
| ● Very low ○ Low ○ Moderate ○ High ○ No included studies | Overall, the certainty of evidence for most outcomes is very low because of serious risk of bias, inconsistency, indirectness, and imprecision. The certainty of evidence from 4 randomised trials (1247 infants) supporting the benefit of the TPR for the critical outcome BPD is very low because of serious risk of bias, inconsistency, and indirectness. {Dawson 2011 912; Kookna 2019 66; Szyld 2014 165; Thakur 2015 21} The certainty of evidence from 3 randomised trials (1098 infants) {Kookna 2019 66; Szyld 2014 165; Thakur 2015 21} supporting the benefit of the TPR for the important outcome duration of PPV in the delivery room is moderate because of serious risk of bias.  For most critical and important outcomes assessed in the meta analyses of RCTs, the 95% confidence intervals of relative risks (RR) were wide enough to include both potential harm and potential benefit. | The results supporting use of TPR are consistent with animal studies showing beneficial short-term effects of the TPR over the SIB when administering PPV at birth. |
| Values Is there important uncertainty about or variability in how much people value the main outcomes? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Important uncertainty or variability ○ Possibly important uncertainty or variability ● Probably no important uncertainty or variability ○ No important uncertainty or variability | The valuation of the main outcomes is consistent with the values assigned by the ILCOR NLS task force and a larger group of neonatal resuscitation experts. {Strand 2020 328} In addition, parents emphasize the importance of these outcomes. {Webbe 2020 425} |  |
| Balance of effects Does the balance between desirable and undesirable effects favor the intervention or the comparison? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ● Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know | We have considered the balance between the evidence supporting a reduction in risk of BPD (NNT=32) and the lack of evidence of benefit for other outcomes. Moreover, we have considered the reduction in mortality, IVH, severe IVH, and BPD in preterm infants demonstrated in a large observational study. Overall, we suggest that the balance between desirable and undesirable effects for preterm and very preterm newborns probably favors the use of a TPR.  The balance of effects is less clear for late preterm and term infants where the desired effect is limited to decreased duration of PPV, and there is no evidence suggesting undesirable effects. |  |
| Resources required How large are the resource requirements (costs)? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Large costs ○ Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ● Don't know | Although there are no published cost data, pressurized gases, gas blenders, and single-use ventilatory circuits are necessary for a TPR. In contrast, SIBs can function without pressurized gas and some devices can be cleaned for multiple patient use. In addition, whenever a TPR is used, a SIB must be available as a back-up device. It is likely that the costs and resources used may be higher when using the TPR compared to the SIB. | It is possible that a reduction in the risk of BPD among preterm infants may balance the costs associated with TPR use in selected settings. The costs may vary depending on the healthcare resources of the setting. For example, in a setting with high healthcare resources, it is expected that both devices would be used with pressurized gases. In a very low resource setting, a self-inflating bag can be used as a stand alone device. The availability of single-use devices and the costs of use of these vs cleaning and reuse of multiple-use devices may also be a factor. Although they can be operated without a pressurized gas source, SIBs can also be subject to device failure and so whichever device is used, the device should be checked before use and a back-up device may be needed. |
| Certainty of evidence of required resources What is the certainty of the evidence of resource requirements (costs)? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Very low ○ Low ○ Moderate ○ High ● No included studies | No data available.  No studies were found that compared the costs or required resources for routine use of TPR vs SIB. |  |
| Cost effectiveness Does the cost-effectiveness of the intervention favor the intervention or the comparison? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● No included studies | No data available.  No studies were found that compared the cost-effectiveness of routine use of TPR vs SIB. | Although there are no published cost-effectiveness data, it is likely that TPR use increases the cost of delivery room supplies. These costs may be balanced by decreased resource use in the NICU and increased quality-adjusted life years for preterm and very preterm infants if the risk of BPD is decreased. |
| Equity What would be the impact on health equity? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Reduced ● Probably reduced ○ Probably no impact ○ Probably increased ○ Increased ○ Varies ○ Don't know | No data available.  Although there are no data available, a recommendation to use a TPR may reduce health equity. The TPR may differentially benefit preterm infants. The resource requirements for use of a TPR likely mean that providers in low resource settings would not have access to the device, and preterm newborns in low resource settings would not have the same opportunity to benefit from the TPR. | The large observational study included in the review was performed in a World Bank upper middle-income country {Guinsburg 2018 F49}. The TPR was available in the 20 participating public hospitals. The authors commented that the equipment rapidly became available after national guidelines recommended TPR use. |
| Acceptability Is the intervention acceptable to key stakeholders? | | |
| Judgement | Research evidence | Additional considerations |
| ○ No ○ Probably no ○ Probably yes ○ Yes ● Varies ○ Don't know | The TPR is widely used internationally. It is likely to be accepted by stakeholders in settings where the resources are available. In settings with limited resources or where the birth and stabilization of preterm infants is rare, acceptability may be lower. {El-Naggar 2012 491; O'Donnell 2004 208; Murthy 2012 F154; Roehr 2010 493} |  |
| Feasibility Is the intervention feasible to implement? | | |
| Judgement | Research evidence | Additional considerations |
| ○ No ○ Probably no ○ Probably yes ○ Yes ● Varies ○ Don't know | The intervention is feasible to be implemented. Both devices are widely used internationally, and for both, resources for purchase of equipment and training of staff are needed. |  |

# Summary of judgements

|  | **Judgement** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Problem** | No | Probably no | Probably yes | **Yes** |  | Varies | Don't know |
| **Desirable Effects** | Trivial | Small | **Moderate** | Large |  | Varies | Don't know |
| **Undesirable Effects** | Large | Moderate | Small | Trivial |  | Varies | **Don't know** |
| **Certainty of evidence** | **Very low** | Low | Moderate | High |  |  | No included studies |
| **Values** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability |  |  |  |
| **Balance of effects** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | **Probably favors the intervention** | Favors the intervention | Varies | Don't know |
| **Resources required** | Large costs | Moderate costs | Negligible costs and savings | Moderate savings | Large savings | Varies | **Don't know** |
| **Certainty of evidence of required resources** | Very low | Low | Moderate | High |  |  | **No included studies** |
| **Cost effectiveness** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **No included studies** |
| **Equity** | Reduced | **Probably reduced** | Probably no impact | Probably increased | Increased | Varies | Don't know |
| **Acceptability** | No | Probably no | Probably yes | Yes |  | **Varies** | Don't know |
| **Feasibility** | No | Probably no | Probably yes | Yes |  | **Varies** | Don't know |

# Type of recommendation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | **Conditional recommendation for the intervention** | Strong recommendation for the intervention |
| ○ | ○ | ○ | **●** | ○ |

# Conclusions

|  |
| --- |
| Recommendation |
| Where resources permit, we suggest the use of a T-Piece resuscitator over the use of a self-inflating bag in infants receiving positive pressure ventilation at birth. (Weak recommendation, very low certainty of evidence). A self-inflating bag should be available as a back-up device for the T-piece resuscitator (technical remark). |
|  |

|  |
| --- |
| Justification |
| Although the clinical evidence supporting the use of a T-piece resuscitator is of very low certainty, we have also taken into account the direction of evidence from animal studies showing that PEEP facilitates lung aeration.  Animal studies suggest a benefit to using devices providing controlled levels of PEEP and peak inspiratory pressure (PIP) to assist establishment of a functional residual capacity (FRC) during transition of a fluid-filled lung to an air-filled lung capable of supporting air-breathing and to reduce lung damage secondary to barotrauma {Bjorklund 1997 348; Haddad 2017 1405; Hillman 2007 575}. Benchtop and manikins demonstrate more consistent pressures and tidal volumes when using a T-piece resuscitator than a self-inflating bag {Hawkes 2012 797; Hussey 2004 F490}.  However, the certainty of clinical evidence is not sufficient to recommend against using a self-inflating bag during neonatal resuscitation, particularly in regions where pressurized gases are not readily available. |

|  |
| --- |
| Subgroup considerations |
| Although subgroup analyses by gestation were not feasible, in contemporary neonatal practice, BPD is mainly an outcome that affects very preterm infants. Therefore, the reduction in the incidence of BPD suggests that use of a T-piece resuscitator may be of greatest benefit for preterm infants.  For use of self-inflating bag with PEEP valve vs use of self-inflating bag without PEEP valve, the data are too uncertain, so no recommendation can be made. |

|  |
| --- |
| Implementation considerations |
| Implementation will require resources to obtain equipment and train personnel if T-piece devices are not already in use but may be offset by decreased NICU resource utilization after stabilization in the delivery room. |

|  |
| --- |
| Monitoring and evaluation |
| As the recommendation for use of a T-piece resuscitator remains weak and is based on very low certainty evidence, continued monitoring and evaluation is highly recommended. |

|  |
| --- |
| Research priorities |
| There are insufficient studies allowing comparison of benefits and risks of T-piece resuscitators to self-inflating bags by gestation subgroups. Such studies should include outcomes relevant to each gestation subgroup (e.g. severe IVH, BPD, neurodevelopmental impairment for very and extremely preterm infants, admission to neonatal intensive or special care unit, receiving subsequent respiratory support, length of hospital stay, air leaks for term and near-term infants).  There are no studies comparing the cost-effectiveness of routine use of T-piece resuscitators compared to self-inflating bags.  There are no studies specifically comparing how both T-piece resuscitators and self-inflating bags are used in practice (e.g. pressures delivered, set-up time, ease of use, adjustments to pressures made during use, perceived feedback from the device to the user).  There are no studies comparing the flow-inflating bag to either the T-piece resuscitator or the self-inflating bag (with or without PEEP) for neonatal resuscitation.  There are no clinical trials comparing one T-piece device to another and one self-inflating bag to another, although benchtop experiments demonstrate variations in performance that are of potential clinical importance. The specific devices used in comparative studies should be reported {Hinder 2019 F122; Tracy 2019 F403}. |
| References |

Bjorklund LJ, Ingimarsson J, Curstedt T, John J, Robertson B, Werner O, Vilstrup CT. Manual ventilation with a few large breaths at birth compromises the therapeutic effect of subsequent surfactant replacement in immature lambs. Pediatr Res. 1997;42:348–355.

Dawson JA, Schmolzer GM, Kamlin CO et al. Oxygenation with T-piece versus self-inflating bag for ventilation of extremely preterm infants at birth: a randomized controlled trial. J Pediatr 2011,158:912–918 e1–2

El-Naggar W, McNamara PJ. Delivery room resuscitation of preterm infants in Canada: current practice and views of neonatologists at level III centers. J Perinatol. 2012;32(7):491-7.

Guinsburg R, de Almeida MFB, de Castro JS, Gonçalves-Ferri WA, Marques PF, Caldas JPS, Krebs VLJ, Souza Rugolo LMS, de Almeida JHCL, Luz JH, Procianoy RS, Duarte JLMB, Penido MG, Ferreira DMLM, Alves Filho N, Diniz EMA, Santos JP, Acquesta AL, Santos CND, Gonzalez MRC, da Silva RPVC, Meneses J, Lopes JMA, Martinez FE. T-piece versus self-inflating bag ventilation in preterm neonates at birth. Arch Dis Child Fetal Neonatal Ed. 2018;103(1):F49-F55.

Haddad LB, Mascaretti RS, Valle LAPA, Rebello CM. A self-inflating bag may cause hypocapnia in a rabbit model of manual ventilation compared to the T-piece resuscitator. Am J Perinatol. 2017;34(14):1405-1410.

Hawkes CP, Ryan CA, Dempsey EM. Comparison of the T-piece resuscitator with other neonatal manual ventilation devices: a qualitative review. Resuscitation. 2012;83:797-802.

Hillman NH, Moss TJ, Kallapur SG, Bachurski CJ, Pillow JJ, Polglase GR, Nitsos I, Kramer BW, Jobe AH. Brief, large tidal volume ventilation initiates lung injury and a systemic response in fetal sheep. Am J Respir Crit Care Med. 2007;176:575–581.

Hinder M, McEwan A, Drevhammer T, Donaldson S, Tracy MB. T-piece resuscitators: how do they compare? Arch Dis Child Fetal Neonatal Ed. 2019;104:F122-F127.

Hussey SG, Ryan CA, Murphy BP. Comparison of three manual ventilation devices using an intubated mannequin. Arch Dis Child Fetal Neonatal Ed. 2004;89:F490-F493.

Kookna S, Ajay Singh K, Pandit S, Dhawan N. T-Piece Resuscitator or Self Inflating Bag for Positive Pressure Ventilation during Neonatal Resuscitation: A Randomized Controlled Trial. IOSR Journal of Dental and Medical Sciences (IOSR-JDMS) 2019;18:66-74.

Murthy V, Rao N, Fox GF, Milner AD, Campbell M, Greenough A. Survey of UK newborn resuscitation practices. Arch Dis Child Fetal Neonatal Ed. 2012;97(2):F154-5.

O'Donnell CP, Davis PG, Morley CJ. Neonatal resuscitation: review of ventilation equipment and survey of practice in Australia and New Zealand. J Paediatr Child Health. 2004;40(4):208-1

Roehr CC, Grobe S, Rudiger M, Hummler H, Nelle M, Proquitte H, et al. Delivery room management of very low birth weight infants in Germany, Austria and Switzerland--a comparison of protocols. Eur J Med Res. 2010;15(11):493-503.

Roehr CC, Davis PG, Weiner GM, Jonathan Wyllie J, Wyckoff MH, Trevisanuto D. T-piece resuscitator or self-inflating bag during neonatal resuscitation: a scoping review. Pediatr Res. 2020 Jun 11. doi: 10.1038/s41390-020-1005-4. Online ahead of print.

Strand ML, Simon WM, Wyllie J, Wyckoff MH, Weiner G. Consensus outcome rating for international neonatal resuscitation guidelines. Arch Dis Child Fetal

Neonatal Ed. 2020;105(3):328-330.

Szyld E, Aguilar A, Musante GA, Vain N, Prudent L, Fabres J, Carlo WA; Delivery Room Ventilation Devices Trial Group. Comparison of devices for newborn ventilation in the delivery room. J Pediatr. 2014;165:234-239.

Thakur A, Saluja S, Modi M, et al. T-piece or self inflating bag for positive pressure ventilation during delivery room resuscitation: an RCT. Resuscitation 2015;90:21–4.

Tracy MB, Halliday R, Tracy SK, Hinder MK. Newborn self-inflating manual resuscitators: precision robotic testing of safety and reliability. Arch Dis Child Fetal Neonatal Ed. 2019;104:F403-F408.

Webbe JWH, Duffy JMN, Afonso E, Al-Muzaffar I, Brunton G, Greenough A, Hall NJ, Knight M, Latour JM, Lee-Davey C, Marlow N, Noakes L, Nycyk J, Richard-Löndt A, Wills-Eve B, Modi N, Gale C. Core outcomes in neonatology: development of a core outcome set for neonatal research. Arch Dis Child Fetal Neonatal Ed. 2020 Jul;105(4):425-431

Wyckoff MH, Wyllie J, Aziz K, de Almeida MF, Fabres J, Fawke J, et al. Neonatal Life Support: 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. Circulation. 2020;142(16\_suppl\_1):S185-S221.