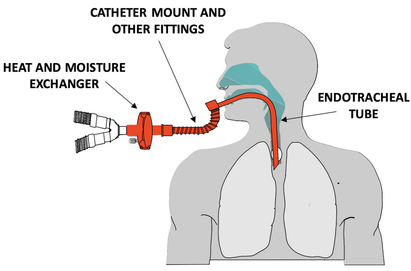
Ventilo

What is instrumental dead space?

By definition, instrumental dead space is the volume after the Y-piece up to the end of the endotracheal tube (ETT) or tracheostomy tube; beyond the ETT the physiologic (or anatomical) dead space begins. During mechanical ventilation, the instrumental dead space can be easily modified. This instrumental dead space can have a substantial impact on the work of breathing during spontaneous ventilation[1,2] and on gas exchanges during controlled ventilation[3-7].



Instrumental dead space includes the humidification system when using heat and moisture exchangers (HME) (the volume of most HME ranging from 30–95 mL[8]), any connectors (catheter mounts, connector for end tidal CO_2 ($EtCO_2$) monitoring, connector for closed suction circuits, or other connectors), ETTs (11–24 mL, depending on their length and diameter) and tracheostomy tubes (3–8 mL depending on their length and diameter)[9].

Dead space of the most common heat and moisture exchanger (HME)[8]

HME	Manufacturer	Dead space mL (manufacturer data)
Hygrovent	Peters	95
Hygrobac	Mallinckrodt	95
Hygrovent S	Peters	55
Hygrobac S	Mallinckrodt	45
HMEF 1000	Datex	77
9000/100	Allégiance	90
Servo Humidifier 172 (173)	Siemens	
Humid Vent Filter Compact	Hudson	35
All Round Filter MAP05	Peters	89,5
Hygroster	Mallinckrodt	95
Slimline HMEF 9040/01	Sodis	45
BACT HME	Ansell	70
Filtra flux	Vygon	22
HME 12 BASIC	Ansell	81
Humid Vent 2	Hudson	29
Servo Humidifier 162 (163)	Siemens	
FE52A	Rüsch	84
Humid Vent 2S	Hudson	29
9040/01	Allégiance	47
9000/01	Allégiance	90
Thermovent 1200	Sims	32
BB 100E	Pall	85
BB100	Pall	90
Clear Therm +	Intersurgical	52
Filta Therm	Intersurgical	42
Stérivent	Mallinckrodt	92
Iso Gard Hepa Light	Hudson	80
Filtraflux	Vygon	
Stérivent S	Mallinckrodt	62
BB 2215	Pall	
8222/01	Allégiance	74
Maxipleat	Sodis	74
HME 10	Ansell	27
BB25	Pall	35
All Round Filter MAP01	Peters	70
BB2000AP	Pall	35
BACT TRAP HEPA	Ansell	
Clear Guard Midi	Intersurgical	24
Clear Therm Midi	Intersurgical	24
Barr Vent	Peters	101
Stérivent Mini	Mallinckrodt	35
4444/66	Allégiance	47
Filta Guard	Intersurgical	56
4000/01	Allégiance	38
Clear Guard II	Intersurgical	42
ISO GUARD FILTER S	Hudson	26
Barr Vent S	Peters	37
Barrierbac S	Mallinckrodt	35

The order of the HME shown in this table is a function of their humidification performances. In Lellouche et al., 2009, the efficiency of the HME in terms of gas humidification was measured. The 20 most efficient HMEs (delivered humidity >28 mgH_2O/L) had an average dead space of 64 mL [8].

Several studies have shown that dead space reduction associated with using a Heated Humidifier during controlled mechanical ventilation can have a significant impact on gas exchanges with a reduction in $PaCO_2$ proportional to the reduction in dead space[3-7]. In the study by Prat et al., 2003 in 10 patients with acute respiratory distress syndrome (ARDS) and hypercapnia, maximum dead space (95 mL HME and 25 mL catheter mount) to minimum dead space (heated humidifier and no catheter mount), $PaCO_2$ was reduced from 80 to 63 mmHg without any other ventilator setting being modified [5]. In the study by Moran et al., 2006 in 17 patients with ARDS, switching from a HME to a heated humidifier reduced $PaCO_2$ from 46 to 40 mmHg [4]. In a third period, the V_T reduction to restore the initial $PaCO_2$, after having reduced the dead space, allowed the plateau pressure to be reduced by 4 cmH_2O [4].

However, in these studies conducted more than 10 years ago, V_T was often higher and respiratory rates lower than today [3-5]. It is likely that the impact of dead space reduction should be even greater now since protective ventilation is more "aggressive" (V_T <8 mL/kg and RR >25/min).

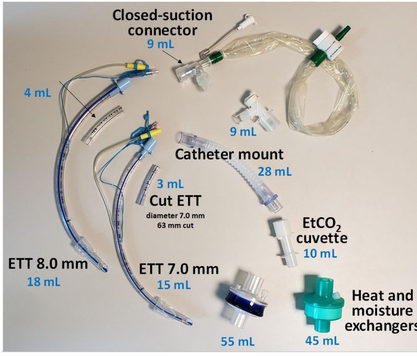
Endotracheal tubes dead space[9]

Tube	Internal diameter, mm	Length, cm	Dead space, mL
Endotracheal			
No 6.0	6	31.5	11
No 7.0	7	34.5	15
No 7.5	7.5	35.0	16.5
No 8.0	8	35.5	18
No 8.5	8.5	36.5	24
Tracheostomy			
Size 4	5	10	3
Size 6	7	12	5
Size 8	8.5	12	6
Size 10	9	12	8

Reducing instrumental dead space

During protective mechanical ventilation, instrumental dead space should be reduced to enable V_T to be reduced as much as possible[10], while remaining efficient regarding gas exchange and in particular on $PaCO_2$ reduction.

Cutting an ETT saves only a few mL of dead space with little clinical impact [11], removing catheter mounts and other connectors reduces dead space up to 40 mL, dead space reduction after removal of a HME ranges from 30–95 mL [8]. It is therefore recommended to avoid the use of, often unnecessary, catheter mounts and to avoid the use of HME as a gas humidification system, especially during ARDS[10]. This guidance also stands for protective ventilation situations where the respiratory rate is high and cannot be increased (presence of auto-PEEP), with reduced tidal volumes, or where rapid control of respiratory or mixed acidosis is required [10].



References

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