The invention relates to a flexible tubular suction catheter for introduction into the trachea and the bronchial system, containing at least one lumen passing from the proximal end to the distal end of the suction catheter for withdrawing fluids from the lungs by suction.

Suction catheters of the generic type with one lumen for suction are disclosed in DE-AS 23 64 119 and suction catheters with two continuous lumina, the first of which serves to suck and the second to lead through medicines, are disclosed in DE-PS 36 08 943. Catheters for simultaneous artificial respiration and oxygen supply, which are inserted into the trachea, are for example disclosed in US-PS 43 00 550. An endotracheal respiration tube, into which a permanent catheter for withdrawal by suction is inserted, is disclosed in DE-OS 23 08 400.

In order to make possible the introduction of an endotracheal tube into the larynx and the upper trachea without irritation and as free of pain as possible, it has already been proposed according to DE-GM 70 35 135 that the distal end of an endotracheal tube be provided with a first curve and its proximal end with a second curve in order to form the tube approximately in an S-shape simulating the curve of the respiratory tract of the patient. Such an endotracheal tube cannot, however, be introduced into the bronchi, in order to apply suction directly at the lung.

A bronchial catheter is also known from DE-AS 12 11 360, the catheter having a tubular outer guide element of a rigid material, the distal end of which is bent approximately through 90° adapting to the respiratory tract in order to be able to be passed more easily past the larynx.

The application of suction to the trachea and bronchial chamber must occur by way of the right lobe

of the lung as well as the left lobe of the lung. Because of the rather asymmetric formation of the bifurcation, the result however in practice is that with normal introduction, the generally straight, tubular flexible suction catheters are introduced through the trachea as a rule up to 70% into the right lobe of the lung and at the most up to 30% into the left lobe of the lung. In order to remedy this drawback, suction catheters are already known which are bent twice at the end, in each case offset relative to each other by 90°, so that they form a three-dimensional hook; however a separate suction catheter bent in the corresponding two different directions and planes is necessary for each lobe of the lung. The brochure for the Métras-catheter with the catalogue number 1645-1651 also shows a pair of suction catheters bent in two different directions and planes. Finally in US-A-4 716 896, a catheter is disclosed which is especially suitable for the left bronchial branch. This means considerable expense during treatment as, in each case, a separate suction catheter is introduced for the suction of the lung on the right side and for the suction of the lung on the left side respectively, whereby the suction catheters are not to be mixed up.

The underlying object of the invention is to form a flexible tubular suction catheter for the bronchial system, so that the same suction catheter can be introduced perfectly and almost certainly in a predetermined manner into the right lobe of the lung or into the left lobe of the lung.

This object is achieved according to the invention in that the region of the distal end of the suction catheter is formed in a wave shape in the longitudinal direction of the suction catheter and, to be precise, it is waved approximately in a W-shape, this undulation extending in only one plane. The

distal end region of the suction catheter is, therefore, only waved in one plane in the form of a spring, so that now, during introduction into the trachea or when leading through a respiratory tube, it comes to rest on the walls of the trachea or the respiratory tube on one side with a wave crest and on the other side with the end, and in this way the distal end with the lumen exit can be introduced in a targeted manner past the bifurcation into one of the two forks of the lobes of the lung. Depending on the direction in which the distal waved end of the suction catheter is pointing, it is introduced in a controlled manner into the right or the left lobe of the lung. The selection of whether the suction catheter should be introduced into the right or left lobe of the lung, can be triggered by the attitude of the suction catheter or rotation by 180°.

In the approximately W-shaped undulation of the distal end, the first wave loop and the free flank of the "W" can form the two diametrically opposed bearing points or contact points of the suction catheter in the trachea, by means of which the defined guidance of the suction catheter into the lobes of the lung is made possible. The flexible suction catheter of plastics or natural rubber or soft rubber should not, however, be too soft as it then no longer has an adequate stability and could easily snap off or tend to twist. The W-shaped undulation is formed as a durable permanent deformation of the distal end region of the flexible suction catheter.

The suction catheters to be introduced into the bronchi through the trachea usually have a length of approximately 30 to 55 cm. Advantageously, it is provided according to the invention that the distal region up to the end of the suction catheter is formed in a wave shape with a length of approximately 40 to 80

mm. The fork region at the bifurcation is therefore also bridged perfectly and the introduction of the distal end of the suction catheter into the desired lobe of the lung is assisted.

In a further embodiment of the invention, it is provided that the undulation attenuates to the distal end. This means that the first wave crest led out of the longitudinal axis of the suction catheter has the greatest amplitude and the following wave crests in the direction of the distal end have in each case decreasing amplitudes. An adequate guidance of the distal end and of the suction catheter is already achieved with waves at the end region over at least one to approximately two wave lengths. In order to achieve an improvement of the spring action, and therefore of the feeding action and the guidance of the distal end of the suction catheter when introducing this through the trachea or a respiratory tube, it is furthermore provided that the wave longitudinal axis is inclined relative to the longitudinal axis of the suction catheter. This inclination can have an angle ß of approximately 10 to 40 degrees, preferably 15 to 35 degrees.

Corresponding to the geometry of the trachea and bronchi, suction catheters usually have an average outer diameter of approximately 3 to 10 mm with a lumen diameter of approximately 2 to 8 mm. Advantageously it is now provided that the size of the maximum amplitude of the first wave peak corresponds approximately to the size of the average outer diameter of the suction catheter. With a very small outer diameter of the suction catheter, the amplitude can, however, also be greater than this; this is also the case when forming approximately only one and a half waves at the distal end of the suction catheter. The wave amplitudes of the end from the longitudinal axis of the suction

catheter in both directions should not exceed in total a dimension which corresponds approximately to two or three times the average outer diameter of the suction catheter. Such a suction catheter is still able to be inserted into the bronchi through a respiratory tube.

In a further design of the suction catheter according to the invention, it is provided that the waved distal end terminates with a wave flank deflected at an acute angle a which can be about 10 to 45 degrees, from the longitudinal axis of the suction catheter.

In order to avoid damage to the mucous membrane the suction catheter can be surrounded in a known manner on the outside at the distal end with an annular ring. One or several radial openings can likewise be provided distributed over the periphery in the region of the distal end. Usually the exit of the lumen and the end cross-section of the distal end extend approximately perpendicularly to the longitudinal axis of the suction catheter. Owing to the wave-shaped formation of the end according to the invention, this no longer extends perpendicularly to the longitudinal axis of the suction catheter due to the deflection. If the suction catheter is not only to be used for suction, but, rather, for example, with a double-lumen formation, also for the introduction of medicines, then it can be advantageous to shape the one-lumen and double-lumen suction catheter according to the invention, in that the end cross-section of the distal end extends perpendicularly to the longitudinal axis of the wave flank and therefore is formed, in practice, in an undercut manner. The issue of medicines in jet form in the direction of the longitudinal axis of the suction catheter into the lung channels is thereby guaranteed. The distal end of the suction catheter can also be formed in a rounded-off

manner.

The suction catheter according to the invention is suitable for the introduction into the lobe of the lung on the right side as well as on the left side. In this process the procedure is that once the suction catheter has been introduced into, for example, the right lobe of the lung it is then pulled back again partially into the trachea, then rotated about the longitudinal axis by 180 degrees, and then inserted again, whereupon it now arrives in the left lobe of the lung. It is advantageous to mark the suction catheter along its whole length with length dimensions. In this way it can be ensured that extraction of the suction catheter from one lobe of the lung, which is necessary in treatment in order to insert it into the other lobe of the lung again after rotation, can occur to the required degree, i.e. neither too little nor too much. Moreover it is possible to provide the suction catheter with an X-ray contrast band or the like, which extends over the whole length of the suction catheter.

In order to prevent the suction catheter sticking to the walls of the trachea or a respiratory tube, the suction catheter can have a smooth outer skin and if necessary an additional sliding coat, e.g. based on silicon.

According to a further proposal of the invention the suction catheter is finely ribbed on the outside i.e. provided with ribs extending in the longitudinal extension of the suction catheter. In this connection, a lot of small ribs are preferred, between which small grooves extend. At least four, preferably six or more ribs with a height of approximately 30 to 700 μ are provided evenly distributed over the outer periphery of the suction catheter. In this way according to the invention, the

contact surface of the suction catheter on the trachea or on the inside of the respiratory tube is reduced when the suction catheter is being inserted, the friction face thereby becoming smaller and the suction catheter sliding more easily and in an improved manner, so that it is not distorted (does not twist) when being inserted into the trachea or the respiratory tube.

The design according to the invention is suitable for application with all types of suction catheters which are inserted into the trachea for treatment of the bronchial system, through the nose, wind pipe as well as through the trachea, with or without a respiratory tube. For the right and left positioning of the suction catheter equipped according to the invention for insertion into the right or left lobe of the lung, a corresponding mark can be provided on the proximal end of the suction catheter.

The suction catheter according to the invention can be manufactured by extrusion of a tubular plastics hollow profile with external ribs. This plastics hollow profile is stretched and then cut into predetermined lengths or vice versa. With these flexible tubular sections corresponding to the suction catheter, the later distal end region must still be waved. For this purpose it is proposed that a supporting wire having the desired undulation be deformed and that this preformed supporting wire be inserted into the end of the tubular section, with the tubular section fitting tightly on the supporting wire. The waved section preformed thus is then heated with the supporting wire to a deformation temperature for the plastic of between 65 and 120°C, depending on the plastics material, and then plunged immediately into a cold water bath. The supporting wire can then be removed. In order that the supporting wire does not adhere to the section, it can be coated with a non-

stick layer, e.g. Teflon. It is also possible to lay the flexible tubular section in a two-part mould, which corresponds to the outer contour of the suction catheter with a waved distal end, and to heat the mould with the section laid therein to a sufficient deformation temperature for the plastics material and then to chill the preformed section. In each case, a permanent deformation of the distal end region of the suction catheter in the desired waved shape is achieved, thus simultaneously causing a certain reinforcement of the catheter end, the introduction of the suction catheter into the bronchi being facilitated as a result.

The invention will be illustrated in the drawing using exemplifying embodiments.

Figure 1 shows a one-lumen suction catheter in plan view.

Figure 2 shows a diagrammatic view of the formation of the waved distal end region.

Figures 3 and 4 show the diagrammatic view of the introduction of the suction catheter into the lobes of the lung.

Figure 5 shows a two-lumen suction catheter in plan view.

Figure 6 shows in partial section a suction catheter with different distal ends.

Figure 7 shows a ribbed suction catheter in plan view.

Figure 8 shows a cross-section DD of Figure 7.

The suction catheter according to Figure 1 with a length of approximately 50 cm is made of flexible transparent thermoplastic plastics material by means of extrusion with subsequent stretching and permanent plastic deformation. The suction catheter 1 has a lumen 10 for suction passing from the proximal

end 12 to the distal end 13 with a lung exit. The diameter of the lumen 10 amounts to approximately four millimetres, with an outer diameter of approximately 6 to 7mm. At the proximal end 12 there is the funnel 4 inserted with the connecting piece 41 into the lumen input. It is also possible to preform the funnel 4 directly onto the proximal end 12 of the suction catheter, as a result of which this obtains a conically extended end. In the region of the distal end 13, there are provided in the suction catheter, radial openings distributed over the periphery which continue up to the lumen, at least one opening being formed. The distal end can be surrounded on the outside by an annular ring 6. The suction catheter 1 has the longitudinal axis 11. The distal region 2 is formed waved to the end 13 over the length L. The undulation occurs in one plane and has an approximately W-shaped form, with the undulation attenuating to the distal end 13, i.e. with a decreasing amplitude of the wave crests, see also Figure 2. The example shown in Figure 1 has approximately the original size. The longitudinal axis 15 of the wave is slightly inclined relative to the longitudinal axis 11 of the suction catheter 1 by the angle ß. This is made possible for example in that the suction catheter is slightly deflected, with a very small wave trough WO, from the longitudinal axis 11 at the beginning of the undulation and then transformed into the desired W-shape with the first large wave with the maximum amplitude. The undulation of the distal end region should so occur that a contact point can be obtained at each side on the trachea or the respiratory tube in relation to the longitudinal axis 11 of the suction catheter, through which the suction catheter is introduced in a supported manner, so that it cannot snap off. In the example shown according to Figure 1 and 2, these are the

contact points W1 on the first maximum wave crest and, on the opposing side, the contact point W4 i.e. the end of the free flank of the last wave at the distal end. The trachea is denoted schematically in Figure 2 by 3.

When considering the normally predetermined outer diameter of the suction catheter, the maximum amplitude A1 should correspond approximately to the average outer diameter of the suction catheter. The sum, to be precise the maximum sum A, of the wave amplitudes at both sides of the longitudinal axis 11 of the suction catheter should not exceed three times the outer diameter of the suction catheter, preferably only being two to two and a half times the outer diameter. The waved end has in particular three formed wave crests around the wave longitudinal axis 15, namely W1, W2, W3 according to Figure 2. The end of the corrugated W terminates in the open flank W4, the longitudinal axis 11a of which, see Figure 1, is inclined at the angle a relative to the longitudinal axis 11 of the suction catheter. The opening in lumen 10 occurs in the shown example according to Figure 1 perpendicularly to the flank axis 11a. It is however also possible to shape this opening or the end cross-section so that when the distal region is deflected, this opening nevertheless extends perpendicularly to the longitudinal axis 11 of the suction catheter. Examples are represented in the embodiments according to Figures 6a and 6c. Here the end cross-section at the distal end 13 is undercut, slanting relative to the flank axis 11a, so that the lumen exit extends approximately perpendicular to the longitudinal axis 11 of the suction catheter and correspondingly there can thus be suction axially from the lung, or medicines can be introduced in the axial direction 11.

Even with suction catheters on the distal end of which there is preformed an annular ring 6, see

cutaway portion 6b, an end cross-section can be achieved which extends perpendicular to the longitudinal axis 11 of the suction catheter through a corresponding slanting of the deflected flank, see Figure 6c. This is important if two-lumen suction catheters are used, where medicine should be introduced as deeply as possible into the lung through one lumen. Such a two-lumen suction catheter is shown in Figure 5. In addition to the lumen 10 for suction, it is formed with a further lumen 14 passing from the proximal end to the distal end for guiding through medicine. The lumen 14 has, however, a smaller cross-section than the lumen 10.

The lumen 14 has a diameter of approximately one to a maximum of two millimetres, the lumen 10 having a diameter of approximately three to four millimetres. A tube 7 is inserted into the lumen 14 in the region of the proximal end of the suction catheter through an opening 142 in the suction catheter, at the end of which there is provided a nozzle piece 8 for a syringe. The lumina 10, 14 extend conically at the proximal end with their inputs 101, 141, in order to be able to insert corresponding connections. At the distal end 13 of the suction catheter 1, which is also provided with the annular ring 6 and with radial openings 5, the lumen 14 terminates in the lumen 10. The distal end region 2 of the suction catheter 1 is waved in a W-shape. The lumina 10,14 are only shown diagrammatically.

Shown in Figures 3 and 4 is the introduction of the suction catheter 1 with the waved distal end according to the invention through the trachea 3 into the lobes 32, 33 of the lung. In this process, it is advantageous further to provide a respiratory tube 9 indicated in dots in the upper trachea 3 as an introductory aid. At the end of the trachea, the

passages branch above the bifurcation 31 into the right lobe of the lung 32 and the left lobe of the lung 33. Depending on the guidance and attitude of the suction catheter 1 with the waved end region 2, a controlled introduction of the suction catheter occurs during insertion in the direction of the arrow by way of the bifurcation into the left lobe of the lung 33 according to Figure 3 or into the right lobe of the lung 32 according to Figure 4. The restricted guidance of the waved distal region 2 of the suction catheter along the walls i.e. the mucous membrane, the trachea and the respiratory tube with the contact points can be seen in Figures 3 and 4. The introduction of the suction catheter 1 occurs in the direction of the arrow P. With simple rotation of the suction catheter 1 by 180 degrees about its longitudinal axis, the same suction catheter can be used alternately for safe introduction into the right or the left lobe of the lung.

If the suction catheter was introduced first of all into a lobe of the lung, once the suction of the suction catheter has terminated, a portion can be pulled out in the opposite direction to the arrow direction P, until it is located with the distal end again completely inside the trachea 3. Then the suction catheter is rotated about 180 degrees and introduced again into the other lobe of the lung with renewed pushing in the direction of the arrow P.

In order to reduce the friction of the suction catheter during insertion through the respiratory tube 9 or the trachea 3 the suction catheter, see Figures 7 and 8, is profiled advantageously on its surface. In this connection, ribs 16 and grooves 17 are formed extending preferably in the longitudinal extension of the suction catheter, which ribs and grooves are distributed evenly over the periphery and extend from the proximal end 12 to the

distal end 13 or to the annular ring 6 or the holes 5. In the case where a nozzle piece should be placed outside at the proximal end 12 of the suction catheter, the ribs in this region can be removed or levelled.

Figure 8 shows in an enlargement, a cross-section through a ribbed suction catheter. Many fine ribs are formed evenly, with the ribs having a height, or the grooves 17 a depth, of approximately 30 to approximately 700 μ, depending on the diameter of the suction catheter.

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Claims

1. A flexible tubular suction catheter (1) for introduction into the trachea and the bronchial system, containing at least one lumen (10) passing from the proximal end (12) to the distal end (13) of the suction catheter for withdrawing fluids from the lung by suction, characterised in that the region (2) of the distal end of the suction catheter (1) is waved approximately in a W-shape in the longitudinal extension of the suction catheter and this waving extends in only one plane.

2. A suction catheter according to claim 1, characterised in that the distal region (2) is formed in a wave shape to a length of approximately 40 to 80 mm.

3. A suction catheter according to one of claims 1 to 2, characterised in that the waves of the wave-shaped region (2) attenuate towards the distal end (13).

4. A suction catheter according to claim 1, characterised in that the waved distal region (2) extends over at least one and a half to approximately two wavelengths.

5. A suction catheter according to claims 1 to 4, characterised in that the wavelength axis (15) of the waves of the distal region (2) is slightly inclined relative to the longitudinal axis (11) of the suction catheter.

6. A suction catheter according to claim 5, characterised in that the wavelength axis (15) of the waves of the distal region (2) is inclined by an angle ß of approximately 10 to 40 degrees relative to the longitudinal axis (11) of the suction catheter.

7. A suction catheter according to one of claims 1 to 6, characterised in that the size of the maximum amplitude (A1) of the first wave peak (W1) of

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the waves at the distal region (2) corresponds approximately to the size of the average outer diameter of the suction catheter.

8. A suction catheter according to one of claims 1 to 7, characterised in that it has an average outer diameter of approximately three to ten millimetres.

9. A suction catheter according to one of claims 1 to 8, characterised in that the distal end (13) is formed from a wave flank (W4) deflected at an acute angle a from the longitudinal axis (11) of the suction catheter (1).

10. A suction catheter according to one of claims 1 to 9, characterised in that the wave amplitudes of the waved distal region (2) from the longitudinal axis (11) of the suction catheter (1) do not exceed in total an amount (A) which corresponds approximately to the size of two to a maximum of three times the average outer diameter of the suction catheter.

11. A suction catheter according to one of claims 1 to 10, characterised in that the distal end (13) is surrounded on the outside by an annular ring (6).

12. A suction catheter according to one of claims 1 to 11, characterised in that the end cross-section of the distal end (13) extends approximately perpendicular to the longitudinal axis (11) of the suction catheter (1).

13. A suction catheter according to one of claims 1 to 4, characterised in that it is marked outside with length measurements.

14. A suction catheter according to one of claims 1 to 3, characterised in that it is provided with an x-ray contrast strip or the like extending in the longitudinal extension of the suction catheter from

the distal to the proximal end.

15. A suction catheter according to one of claims 1 to 14, characterised in that it is equipped on the outside with ribs (16) extending in the longitudinal extension of the suction catheter (1).

16. A suction catheter according to claim 15, characterised in that at least four, preferably six or more, ribs (16) of a height of approximately 30 to 700 μ are distributed evenly over the periphery of the suction catheter.