Balloons

Here, balloons serve as analogies for bubbles. The important points are that a bubble's skin causes its internal pressure to be greater than ambient, and the pressure inside small bubbles is greater than larger bubbles.

Other physical effects such as Boyle's law and tissue compression also affect the internal pressure of bubbles in divers. All of this is important for developing bubble decompression tables because ascents are limited by the difference between bubble internal pressure and the gas tensions in surrounding tissues.

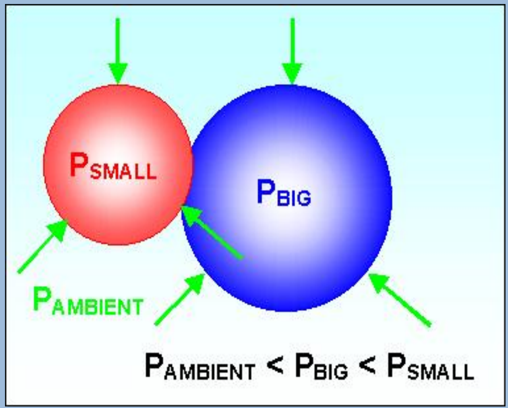

Fig. B2. As with bubbles, the pressure inside balloons is greater than ambient. Because the Laplacian skin tension varies as 1/radius, the pressure inside the smaller balloon is larger than the pressure inside the big balloon.

So, we need to account for the physical effects that influence bubble pressure in order to quantify ascent criteria. This also allows us to use sound physical principles to control the inflation of bubbles. These guidelines hold generally, regardless of whether we are talking about gelatin, balloons, beer or humans.

Skin Tension

When you begin to blow up a balloon, it's difficult to inflate. As it grows, it gets easier. There are a number of reasons why this is so, but for our purposes, say that it is due to skin tension. The rubber skin exerts an inward force over the surface, causing the pressure inside the balloon to be higher than external pressure (resulting in a "pop" when pierced).

Skin tension varies inversely with the radius of a balloon. This causes the pressure inside a smaller balloon to be greater than a larger balloon, --resulting in the decrease in inflation resistance as the balloon grows. Of course, it never becomes effortless to blow up a balloon -unless it pops. So, we see that there is an important effect for large bubbles also. This is the elasticity, or compliance (springy-ness) of displaced tissue surrounding the bubble. This volume-dependent effect serves to aid shrinking large bubbles just as skin tension helps to collapse smaller bubbles.

Diffusion

If a balloon is inflated with helium and then left for a few days, it will deflate. This is obviously due to the helium "leaking," or diffusing, through the skin. The balloon's skin is permeable to He, allowing outward flow to occur. Furthermore, it is the pressure gradient *G* from inside the balloon to outside the balloon that drives the gas outward. Even if the balloon were immersed in pure helium, the balloon would still collapse because its internal pressure would be higher than external due to the skin tension (this is similar to the concept of the oxygen window in living creatures).

Internal Pressure

Consider the following: Two identical balloons are inflated, one more than the other. A closed valve connects the large and the small balloons.

Question: When the valve is opened, what happens?

Answer: A reasonable guess is that gas would flow from high pressure to low until pressures equalized on either side of the valve. Because a smaller balloon has higher internal pressure than a larger, we see the gas must flow from the small to the large balloon. Counter to the naive idea that the two balloons would end up with identical sizes, the smaller balloon deflates as the larger balloon inflates!