To derive the parametric equations for the Witch of Agnesi we should refer to the graph below and assume certain equations.

Assume the following:
1.) $x = AQ$
2.) $y = 2 - AB \sin(t)$
3.) $AB \cdot OA = (AQ)$

We know that $\tan(t) = y/x$. This also tells us that $\cot(t) = x/y$.

We can solve this for $x$ and get

$$x = y \cot(t).$$

As in our example, $y=2$, we can conclude that the parametric equation for $x$ is:

$$x = 2 \cot(t)$$
Now that we have the parametric equation for $x$, we can now the equation for $y$.

From equation 3 above, we know that

$$AB = \frac{x^2}{OA}$$

Since $OA$ is the hypotenuse of the triangle,

$$AB = x \cos(t)$$

From our parametric equation for $x$, we can use substitution and get

$$AB = 2 \cot(t) \cos(t)$$

This can be transformed into

$$AB = 2(\cos(t)/\sin(t)) \cos(t)$$

By multiplication we get

$$AB = (2\cos^2(t))/\sin(t)$$

If we substitute this into our equation 2, we have

$$y = 2 - (2\cos^2(t)/\sin(t)) \sin(t)$$

We can now reduce this to

$$y = 2 - 2\cos^2(t)$$

By substituting the trigonometric identity $\cos^2(t) = 1 - \sin^2(t)$, we get

$$y = 2 - 2(1 - \sin^2(t))$$

which reduces to the final parametric equation

$$y = 2\sin^2(t)$$

Thus we get the general parametric equations to the witch of Agnesi:

$$x = 2 \cot(t)$$
$$y = 2 \sin^2(t)$$